JT. COMMITTEE ON PREPARING CALIFORNIA FOR THE 21ST CENTURY

2004 California Nanotechnology Policy Briefing

Applications, Implications and Recommendations

Senator John Vasconcellos and Assemblymember Sarah Reyes, Co-Chairs

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SENATOR JOHN VASCONCELLOS: Let's get started. And even as we started, we _____California _____ a no-majority state before too long. Analysts say by the year 2010 California retirees _____is reported Anglo _____ and our workforce _____ two-thirds _____.

The Committee's Principles and Inclusions were adopted by both Houses on a bipartisan vote. The Index of Inclusion set up a gauge, a benchmark on how to go forward to help _____ culture _____

In that same opening pursuit, we decided technology would be second oncoming _____. So we began that about six to eight months ago and formulate what are the implications and applications of technology?

Bio technology, nanotechnology _____ world.

_____-.look at _____and today _____ nanotechnology which is fast upon us. Defies any kind of prior understanding _____ and we want to know what's going on, what's coming, what we should be alert to and prepared to help the Legislature and Governor to think about, for the public to know good partners and also the potential

So today moving _____on nanotechnology _____.

Susan Hackwood is here to do that shortly on the agenda and we've got panelists following. Especially, we have the man from AMES to discuss the potential of all this new developing technology and then Ms. Hackwood will discuss the report and findings. And then we have two panels, one on the economics. We've asked Assemblyman Dave Cogdill, a Republican, to moderate that one. Then a panel on

environmental, social and legal in technology on not only the unknown, but the profound effects of its development and our own well-being to be moderated by Assemblywoman Hannah-Beth Jackson from Santa Barbara _____.

Her mentor was my high school classmate _____.

And lastly, a moderation and panel on governance. What governments ought to do _____ be involved in ways that _____ and that will be moderated by my precious friend and colleague, Debra Bowen from Marina Del Rey in Southern California.

So I want to give thanks, especially to Ms. Hackwood for her efforts with the report, the CCST and _____ time with your own _____ well. Thanks to the panelists and speakers _____ report Association support of the CCST and their contributions to the state. And also, I have been asked to thank Wilson sports because they provided us, I'm not sure what they do, if they bounce more or what? They last longer. Nanotechnology-designed tennis balls. Because they're here, they last longer. I don't play tennis, I play racquetball, so _____. And then Levi Strauss has provided us with right here, right now nano products in the way of a pair of pants, which I will not model today. So it's not a matter of just coming in the future, it's a matter of this being here now and something _____ our society and what we ought to know about it to be good legislators and make good public policy in all _____.

So to begin this morning - Debra, do you want to open with a statement?

SENATOR DEBRA BOWEN: Apparently, I have a lot of nanotechnology _____ _____ _____.

VASCONCELLOS: Thank you. Heather Barbour is our Chief Consultant and has been with me for a couple of years here, as well as in the district office _____ _____

The way this joint committee works, it needs to be inquisitive , not pejorative; to be positive, rather than negative; to be generative about our future and collaborative. This is why it is a joint committee of both houses, why we insisted we have people of both parties. And the panels are meant to be not people speaking, but people listening to each other and learning and helping all the public, our learning institutes, and the members and ourselves to get a better sense of what's going on. What can we do to keep us _____ _____ _____.

Ways of learning and growing and developing and we welcome you to be a part of this process as equal partners.

So first up, we've asked Meyya Meyyappan from NASA Ames, which is down in my district, to tell us what this looks like in the future from your vantage point. Okay?

DR. MEYYA MEYYAPPAN: I'm going to take about 10 or 15 minutes…

VASCONCELLOS: Is that better? Can you folks out there see this? How about putting the screen so we can they see it? I'll move over here and watch from here. Okay now we're in business. You're on.

MEYYAYPPAN: Okay. Thank you. I'm going to take about 10 or 15 minutes and tell you what is nanotechnology and what are the opportunities and, briefly, also what are the challenges? _____.

Just to give you an idea, what is a nanometer? I have a computer picture of a _____ a human hair and a few other things, and it just gives you an idea of how a nanometer is smaller than the width of a human hair. That is the kind of scale we are looking at in nanotech.

So, given the scale, what we are trying to do with nanotechnology is to kind of create useful or functional materials or systems and devices by controlling matter at these limits here, one percent of a nanometer. But the important thing is just not the length scale, but also there is something else, which is, there are a lot of novel properties that happen because of this length scale. These properties can be physical properties, they can be chemical properties, electrical properties, or biological properties. Just to give one example, so what I show here a bar of gold. So pure gold melts at a temperature of 1064 degrees centigrade. So that's a big bar. If you were to throw it in a furnace and that's the temperature at which it melts. But on the other hand, if you were to take gold as a nano particle, like four or five nanometer particle, gold now melts at a couple hundred degrees sooner or quicker than a bar of gold. So, even a simple thing like melting ore then changes because we are dealing with nano skills. So the time has come where we are seeing a variety of properties; electrical properties, optical properties, magnetic properties, biological properties - all these properties are changing once you reach this so-called "nano skills." So the interesting thing is, what do you do with it? How do you actually exploit it to make useful things, useful devices, useful structures, useful systems? Okay? So that's this business is all about. And people often ask me if nanotechnology is going to be just one technology or is there going to be a "Nano Valley," just like you have Silicon Valley. The answer is actually "no." What it is, is nanotechnology is an enabling technology. We will have an impact on a variety of sectors. Pretty much all across the board. We can start with computing and data storage, the heart and soul of Silicon Valley, and materials, manufacturing, health, medicine, energy, the environment, transportation, national security, the list goes on and on and on. So this nanotechnology is enabling technology. It is not any one single thing. So that is something you've got to keep in mind.

And incidentally, most of these sectors have large and small companies that have formed in California. So in that sense, we pretty much cover all of the sectors. I'll come back it a little later.

So what I want to do is just to give some examples in each of these sectors just to give you an idea of what is in store. So let's start with, actually, electronics and computers. So as we know right now, the silicon revolution is attempting to move on and people often talk about the silicon engine is likely to come to a - you know, the humming will probably stop in about 10 or 15 years.

The so-called "_____." What that means is, basically, it doesn't mean people are going to turn their lights off and go home. They will not be making them any smaller than _____ in about 10 years time and they better _____
price at that time. And so nanotechnology, actually, will enable new processes which, you know, the energy consumption much smaller and also the costs much smaller. The efficiency can be about a million times higher. Those are some of the things which are in store with nanotechnology in electronics.

VASCONCELLOS: It could help our energy problem significantly is what you are saying.

MEYYAYPPAN: Yes, actually, the energy sector fell open backwards, but in this case, the electronics, the power consumption does too. That's going to be - as it gets smaller and smaller and they operate faster and faster, the general tendency is that they consume more power and then we need to have heat dissipation. The computer needs to be cooled. You don't want to have a computer where you turn it on and you do your word processing and simultaneously boil an egg and make your coffee. That's the kind of heat it will put out. In nanotechnology, what people are working on is how to simultaneously how to step down the amount of heat that is going to be pumped out.

VASCONCELLOS: So, would you use more energy or create more energy, or both?

MEYYAYPPAN: It would be using with less energy and also putting out less heat.

VASCONCELLOS: Okay.

MEYYAYPPAN: So that was actually on the processing side. On the data storage side, again, a lot more storage _____ more data storage on smaller nano devices. So, that is some of the positive things on the data storage side.

And also what the future holds is integrating all these things together, be it the largest part of the processing part and then the data storage and also expansion, combining our resources. So if you were to look at it from a grand scale point of view, it'd be like, something like a _____. _____properties and everything, and you also store information, memory; and you can also _____.
So combining all these things, that is something that _____ nanotechnology. So these are some of the benefits we are anticipating in the electronics and computing sector.

So moving on, the next one I have here is health and medicine. You've all heard about, actually, the advances in sequencing the human genome and the large-scale benefit of this we still haven't seen yet. The research community is now focusing on some new techniques which potentially, if successful, would allow the entire human genome to be sequenced in less than a couple of hours. So what that means is, actually, _____. Right now, actually, when someone gets sick and then they go to the doctor, the doctor has seen similar symptoms in hundreds of patients, if not thousands. So it is statistics-

based and likewise in prescribing therapeutics, it is also statistics-based. But if the entire genetic makeup of each individual can be sequenced in an hour or two, what that means is that the person with _____ for example, and the genetic makeup is sequencing, go have a cup of coffee, wait for it, come back and then do the diagnostics, then the therapeutics can be prescribed based on the individual's genetic makeup. That is important in the _____. And all around, hopefully, effective and less expensive in healthcare. The healthcare that is consumed now is approximately 15 or 16 percent _____. So we have to do something about it before it - it is already a monster, and this monster is only getting bigger. So, it is important that nanotechnology focuses in a proper manner to address _____ via new formulations and delivery throughout and also sensors for early warnings and on so forth.

Materials and Manufacturing. This is a big difference, particularly when you want to reach some kind of an educated "what do you do right now?" _____ so on and so forth. Now we actually want to go the other way around. We want to reach the next step by starting from atoms and molecules. So this is the so-called "bottom up" processing. That actually, potentially, can give you lighter, stronger materials with a lot less weight and you can program functions into these computers with multi-functionality. So that is revolutionary in materials and manufacturing.

Energy. On the energy side there are a couple of things. One is actually in the _____ production _____. But that is generally _____. But there is something you can do, particularly in nanotechnology _____ on the utilization _____. If you take a regular light bulb and _____. What that means is every time you _____. The fluorescent bulbs are a little more _____ than the common filament bulbs. The solid state lighting _____ nanotechnology and the efficiency, of course, is in the upper 90s _____. And the electricity consumption - I saw a report from Sandia Labs in Albuquerque,.and they say if every light bulb in the country is replaced by solid state lighting, the amount of energy you save is equivalent to 28 million tons. This is _____ 28 million tons, but the energy you save would be equivalent to all the imports you have coming from the Middle East countries. But the overall electricity consumption itself would go down by 10 percent. That is the kind of impact you are looking at on the energy and subsequently on the environment, too, because the carbon _____, too. So these are interconnected.

And in transportation, in a number of areas _____. That can actually increase fuel efficiency both in the automotive sector and the aerospace sector. And also now you can go toward a hydrogen economy and that will require a whole lot of new sensors under the hood. Particularly the hydrogen economy itself can benefit from nanotechnology. _____ new

battery technology, new fuel cell technology. These are all some of the things that are coming.

National Security and Uses in a Foreign Area. California will get a lot of companies to produce _____ for the Pentagon and typically lightweight military platforms. The average standard is about 70 to 80 tons. And the Army is looking _____. So it's a lightweight platform without sacrificing any functionality of our soldiers security. _____ that is being carried on by our soldiers. They generally tend to carry anywhere around 70 pounds. You can then lose the weight quite _____.

I'll skip the NASA one since we're kind of running late. I just want to summarize here. In nanotechnology, there are incredible opportunities for nanotechnology to impact all aspects of the economic system. I want to restate it is an enabling technology which has a commercial spin to it in all the sectors, and they all have a _____ in California. The competition is pretty stiff within the U.S. _____ across the country, particularly in the large areas like New York and Michigan. But for us, actually, the competition is in the South Pacific _____in Japan and likewise in China, Korea, _____. But we also have the opportunity to work with all of them and to benefit. California has the best _____ universities _____ and the workforce and the _____the largest _____communities. And we also have a history of _____ _____ _____. So with that, I will stop right here.

VASCONCELLOS: Thank you. Okay. Susan Hackwood. She is the Executive Director California Council on Science and Technology, which was created back in legislation authored by my colleague, Sam Farr, now in the U.S. Congress.

SUSAN HACKWOOD: First of all, I would like to express a very sincere thanks to the Committee and to Senators Bowen and Vasconcellos for their leadership with this issue. This unusual and very _____ times _____ about where we should be in the future and how we should prepare ourselves in the future _____. This is wonderful.

I also, on behalf of the Council on Science and Technology, I would like to thank you for asking us to do this report for you. This briefing was put together fairly quickly, so it really is current, current as of a couple of weeks ago. And what we really hope it does is give you the right foundation _____.

What the briefing does is as our normal standard of operation, we brought together leaders in the field who are experts on both industry and academia and we asked them to put together the right information necessary for you to go forward _____. The briefing is comprised of six chapters. The people who are experts in nanotechnology, science and _____. People who representing

business sectors who are responsible for _____. Then we also have people who are interested in social and environmental impact _____.

The seventh chapter in this briefing, which is a list of suggestions of what to do, of who could do what about the issues that are raised in the briefing. So, there is a seventh contribution _____. It is timely. This data is current. I don't whether you saw the WALL STREET JOURNAL this morning, but there is an article about defense capital investment stock prices for nanotech companies that was out this morning. I'll leave you a copy of that.

VASCONCELLOS: Okay. Thank you.

HACKWOOD: So, that's what the report does and let me very briefly go through the key findings with you _____ contributed to these very _____ audience. There will be _____ panels this afternoon, but let me tell you what the bottom lines are.

VASCONCELLOS: Is the report up on your website so people can download it and…

HACKWOOD: It's up on the website. It's in PDF on the website…

VASCONCELLOS: It's also on our website for the Joint Committee, as well. So _____ download it and…

HACKWOOD: Right and you've got copies of it.

(Audience member asking for website.)

HACKWOOD: www.ccst.us

HEATHER BARBOUR: Ours is sen.ca.gov\21st century - 2-1-s-t-century.

HACKWOOD: Ours has kind of easier ring to it. Anyway, let me tell you what the key findings are and then give you the details on them.

The size of the nanotechnology impact on our economy, our world economy, is going to be enormous. It already is large and it's going to go larger. The National Nanotech Initiative is currently about 840 million dollars and venture capital is about 1.2 billion dollars for nanotech. So a lot of money is going into it. The new National Nanotech R&D Initiative is going to give another over three and a half billion over the next four years. So there is a terrific amount of investment into this technology. The predictions are very wide-ranging, but they are all large as to what the impact will be on the economy and _____ of a trillion dollar impact over the next 10 years.

We also know that California is the nation's nanotech leader. It's the world's leader, as we often are, in the emergence of new technologies. California receives the bulk of the venture capital in nanotech, as in everything else. We have the top research universities that are still way out in front in many areas of nanotech and highly competitive with MIT or other top universities. So we have the top research going on.

However, we've got some concerns that this is not necessarily going to translate to an improved quality of life for Californians and for an improved economy. For example - skilled workforce - we have huge problems with producing a workforce adequate to support the growing nanotech industries. And there are serious… I'm sorry.

VASCONCELLOS: Well, that's normal because we're at a time when we have this huge second round baby boom coming into the college-age cohort and because of the state's budget crisis proposal before us to reduce UC enrollments next year and to markedly reduce _____ enrollments if the Cal Grants are cut in half, which means most students won't be able to go to Stanford and Santa Clara _____ school. So those are counter to the need we have for a higher educated workforce at this point in time.

HACKWOOD: Yes, we agree. Also, the community colleges because the technicians that will run these manufacturing capabilities are community college-trained.

Serious environmental and health questions because we are going so fast. What are we doing to catch up on the social implications and the environmental implications?

So, slightly more detail again. Nanotechnology is a convergence of quite a few industries. We will have very significant changes going on in the microelectronics and the biotech and the material sciences industries. It's large.

Current industries will have to evolve because they'll have to do things differently. Silicon manufacturing is very different from doing nanotech, and emerging new industries will be different.

We know from studies from colleagues at UCLA that the emergence of the precursors to the industries, the patenting and the licensing and the article publication is at least as big as biotech, probably a lot larger.

We don't know when these things are going to hit the market. We can't predict. We do know that there are some things on the market right now - you've got a few of them there. Most of those are in coatings. And we don't know when microsurgery is going to happen and we don't know when adapted materials is going to happen, but it's going to be over about a 10-year period. We're going to see the emergence of these industries.

These are the products that are on the market at the moment. A few of them you've got on your desk in front of you. And as I said, most of these are in coatings and changing material properties of substances by coating them with nanotech layers. And so what we'll see in the next few years, an emergence of the electronics, as well as the coatings. The coatings are just the tip of the iceberg of the new products.

We know that California is the nanotech leader. We have a fabulous infrastructure for basic research. We have, not only an industry, but in our research universities, we know that between Los Angeles and the Bay Area we contribute about 20 percent of nationwide publications in nanotech. We have the unique environment for entrepreneurship and innovation. We know that these are all very positive things for us moving forward on nanotech, venture capital, etc.

We are beginning to map out the emergence of companies. These are companies in LA that LARTA mapped out at the end of last year. I'm showing the growth of companies around the UCLA/Santa Barbara region.

But, there are concerns as Meyya just said. Other people aren't standing still. Japan and Europe have huge investments coming into nanotech, as well.

And other states have already developed strategies to promote investment into nanotech. So New York, Texas, Pennsylvania, other countries, China, South Korea, Canada, they all have a nanotech strategy of what to do. So, while we are the leader in the research universities and in our industries, we don't have a strategy - statewide strategy.

VASCONCELLOS: Can you tell us off hand how those, in what format those strategies have been adopted? Are they proclaimed by a governor? Are they adopted by a legislature?

HACKWOOD: It's different for different states, a combination of those things. Yes, we do know.

VASCONCELLOS: Are they set forth in the report?

HACKWOOD: Yes.

VASCONCELLOS: Okay.

HACKWOOD: We also know that some of our systems, universities, like the University of California needs to do a better job at technology licensing and IP transfer; and we know that our low performance in K-12 schools and cost-of-living are very detrimental to the growth of nanotech businesses. So we have a strong positive side, but there are also negative sides. I think one of the strongest negative side is our workforce; inability to produce a workforce. Already about 80 percent of U.S. manufacturers have got serious shortages of qualified workers and that is going to get worse.

Yes?

SENATOR DEBRA BOWEN: And this has been a major issue, not just with nanotech, but with our high tech employment base, generally, and I wonder if you've given any thought to mechanisms other than general funding that would work with the university system to deal with training and education for our high tech workforce. One of the criticisms, and I think it is valid, is that our UC system, our Community College system, to a lesser degree, educate not only California's future workforce, but we also do a pretty good job of educating the workforce in Michigan and Illinois and New York and states with which we are competitors in some sense. So, you know, we - I think we just have to be more creative about how we work to ensure that we are maintaining the future viability of the state's economy and not just exploiting our talent.

HACKWOOD: Well, when you talk about exporting talent, that generally is at the graduate level, not at the undergraduate level. Most of our…

BOWEN: Is that true? Do we know that? I actually don't know.

HACKWOOD: Yes. We know that most of our undergraduates are California-born people.

BOWEN: But do they stay here is the question. Not were they born here, but where do they work when they're…

HACKWOOD: When they graduate? Well, most states would say that California is a magnate for their graduates, because we are a net importer of…

BOWEN: So we should encourage them to do a better job of funding higher education.

(Audience laughter)

HACKWOOD: That's a smart idea. Yes. We usually hear complaints the other way around. That California is still the magnate at the Baccalaureate level. I think where we truly fail is community college and high school, because we don't prepare enough students to come up through the system, and that is reflective of our population. For example the Latino population, 73 percent of the students who fail to graduate from high school come from that population.

BOWEN: Well that has huge impacts for our outreach, but also for programs like AVID, which is one of the most successful high school-based programs, but doesn't exist in many of our high schools that serve this population that have low graduation rates.

VASCONCELLOS: The outreach, partly created after Prop. 39, was passed first by the Regents and then by the people of California and it closed the doors to the University of California to, at least, Latino and African-American students, by in large. We have done outreach to help them reopen and they have had remarkable success. We had a hearing two weeks ago and the research there was really promising. And, the numbers are really, you know - and I was looking at who's here in the room, without disparaging anyone of you being present, it looks like Silicon Valley about 20 years ago, you know, largely white and almost all male. And the future of the state is not that, and in fact, the next majority of California will be Latinos in about the year 2030 and if we keep having four-fifths of their students not finish college, we're not going to be competitive. So, one of the implications we ought to take a look at, either you through the Council or us through our work here, is how do we bring this new opportunity to the diversity of California is that we can sustain it and then sustain the people who are going to be here, too?

HACKWOOD: We would agree with that. It's not just in nanotech, but nanotech is so big and it's going to be so important, we will feel it. And in the report, there are about a dozen recommendations on how to go about making changes in the community colleges in the workforce preparation part of that.

When you get to the Baccalaureate, Masters, and Ph.D., we improve as it goes up. California improves as it goes up. We do need to do things like encourage multidisciplinary subjects in the universities. But it's really at the lower levels that we're in trouble, the workforce.

This is a recent SMALL TIME's ranking of states for nanotech and it has a number of factors it takes into account. How hospitable the state is to the nanotech industry and California ranks number one. But that's, actually, quite a misleading number, because if you look at where we rank on the subdiscipline (and that's over on the right hand side), yes, we rank very highly in research, industry, venture capital, innovation; we don't rank highly in costs and workforce.

BOWEN: You know the other thing that strikes me about this is that California's population, compared to that, for example, New Mexico, is significantly greater. So, on a per individual basis, on a population basis, we're under-performing our potential.

HACKWOOD: Yes, I agree. And I just pulled out the workforce just to show that we go down quickly when you look at workforce issues.

Switching to a different topic than workforce, environmental, health, and ethical questions. I think the most important take home message is that they have to be taken into account during the research and development stage of the nanotech field, and it would be very important to start developing nanoethics and social science programs in the nano field in coincidence with our growth in the research area.

VASCONCELLOS: Did your report explore what kind of mechanisms we could imagine creating that would help?

HACKWOOD: Yes. It makes some suggestions and some of our authors have been making suggestions on this, as well. That includes informing the public so we don't have a genetically modified foods kinds of issue rising over nanotech. We will not have self-replicating nanorobots in the near future, for example.

So, realistic risk benefit analyses are concurrent with the research.

So, the policy implications are that we are out in front, but it's not going to stay there and it doesn't come automatically. We have to make some changes. We do not have a coherent vision in the state. The industries will have to evolve and there are very strong and immediate lessons that we can learn from biotech and microelectronics that w can apply to nanotech.

VASCONCELLOS: Just a thought, maybe it'd be a good idea if some body - and I'm not sure - I would suggest we consider a resolution this year and embody some of these major recommendations get it before the Legislature and have people hear it and wonder about it and begin to get ready for creating that kind of… Maybe it would help us be ready to coincidentally address these emerging questions before they get ahead of us.

HACKWOOD: Okay. Good. The report goes through each part of the state government and suggests what they could be doing in nanotech to help the emergence of this industry. So, for example, the congressional delegation, making sure that we have all our ducks lined up to get the large federal funding opportunities that are coming down the pike.

Perhaps within the Joint Committee on Preparing California for the 21st Century, creating a "Select Committee on New Emerging Technologies" in each House of the Legislature, and identify emerging issues.

Perhaps in the Governor's office, establishing a "Nanotech Research and Advisory Workforce Council." These are all spelled out in the report with details about what a possible charge could be to these groups.

Within K-12, a "Science and Engineering Initiative" that includes nanotechnology and includes the words of nanotechnology so a student knows what anatomies you're in; so the teacher knows what anatomies you're in.

The Office of Planning and Research, this actually comes back to a study we did a few years ago, the tax incentive for small companies and land zoning is not favorable for small company growth.

Within the community college system and our public universities create technician workforce training plans that can span across from community college to the four-year institutions and develop appropriate curricular in conjunction with the emerging industries.

VASCONCELLOS: We should have resolutions and advise all recommendations, have hearings on them, and ask each of the agencies to come and say what they will do about the recommendations.

BOWEN: We ought to do some homework, too, because if we, for example, if we eliminate the Office of Planning and Research, we'd probably want to move some of those functions. But we're going to have some changes - I noticed that the Trade and Commerce Agency, for example, was helpful in this and there are changes there.

VASCONCELLOS: They're gone.

BOWEN: Well, yes - in a box we blew up last year.

VASCONCELLOS: Right.

HACKWOOD: Well again, there are very specific suggestions of what could be done and identifying the agents of change

VASCONCELLOS: I think our role at this point is to pick up on your suggestions and recommendations and give them some currency here in the Legislature and be sure that everyone here and in the Administration pays attention to them, is alert to them, and is brought to address them and their own assessment of them whether or not they ought to be doing these things. I think that dialogue itself will certainly upgrade the level of awareness and consciousness and even action.

HACKWOOD: Right.

VASCONCELLOS: Thanks for giving us a headstart.

HACKWOOD: So, that's in a nutshell, the contents of this. It's got a lot of detail in it. We have people who are willing to, obviously, help flesh this out later.

VASCONCELLOS: Fine. Thank you very much. Thank you very, very much. Any comments? Questions? Debra?

Okay, the first of the three panels, apparently the Assembly is still in session, so we will proceed in their absence. The first panel Economy and Markets, vis-à-vis nanotechnology and the report. Dave Cogdill was to be the here, he's still pending but we have - I'll moderate until he shows.

Victor Hwang of LARTA, the Los Angeles Regional Technology Alliance, I guess. Sean Randolph of BASIC/BAEF, Bay Area Economic Forum; Daryl Hatano, Semiconductor Industry Association; Michael Darby of the UCLA and Joe Stetter, from IIT.

How about some lights. You want the lights still darkened? Are going to use the screen? Okay. Well, we'll operate in the dark then. It's not the first time in this building that's happened.

BOWEN: You know, John, some people say that's our standard operating procedure.

VASCONCELLOS: I'm afraid so; right. So you've been lying to us all, then.

Who's going to start off? Are you up first?

VICTOR HWANG: I'd be happy to start. I have a presentation somewhere around here.

VASCONCELLOS: Go ahead.

HWANG: Is there anyone who knows how to pull it up? You know what, I'll adlib. It'll probably be far more entertaining than reading off a presentation anyway.

VASCONCELLOS: That'll be fine. Entertainment we could use right now to keep us awake in mid afternoon.

HWANG: Hello, my name is Victor Hwang. I'm the Chief Operating Officer at LARTA. I appreciate the chance to be here and thank the Committee for allowing me to speak here.

I just got back from a week in Washington, D.C. and I came back with an incredibly profound insight, and that is that Washington is very cold. Actually, it's a much more profound insight than that. I spent some time with disparate agencies within Washington, probably about a dozen of them. All focused on different aspects of the technology innovation lifecycle. That is, people who are in the process of funding in basic R&D, agencies that care about the other end, which is the industrial application of new innovation, and folks who were trying to do stuff in the middle. And it became clearer and clearer as I talked to them - and I've done many trips in D.C., but this one I think ended up being the most clear - which is that governments are very good at throwing money at R&D, and they can be pretty effective on the industry side in terms of using the new technologies that industries have developed. But they're very bad at trying to be in the middle and trying to develop that process in the middle, the process of innovation and applying that R&D into the marketplace. And I realized that there is an opportunity to really try to step in and to use the resources that we have, both at LARTA and in the state, to try to enact some this process.

LARTA, for those of you who aren't familiar - I guess you guys are pretty familiar with it - we were created by the state 10 years ago, primarily to the interface for the state with industry. So, we work with thousands of tech companies, including many of the nanospace. We've done a lot of research studies on nanotech in particular, but other industries - and I appreciate Susan for using one our maps in her presentation. What we've found over time is that California, in many ways, in effect becomes a great R&D shop for the rest of America because we get a lot of dollars invested in innovation and basic research, and we get a lot of the best researchers in the world. But what happens is so much of that discovery ends up getting either licensed outwards or they turn into small companies which get acquired by large companies outside of California, or we develop the innovation that then gets taken overseas to develop large numbers of jobs overseas, as well. And part it is something to be expected. I mean it's the nature of innovation to always be in flux and always expect that the things that you trade will be copies by others. It's the best form of flattery in many ways. But at the same time, there's a lot that we can do to try to foster that at home because there's a lot of states that are in the business now of trying to compete with California.

Many of the innovations that California had to begin with, I mean Silicon Valley and its development was not necessarily an intentional one. It was one that we kind of look back in hindsight and take credit for, but really it was an accident. So many of things that caused Silicon Valley have been studied in

hindsight now by a lot of famous researchers, including AnnaLee Saxenian from Berkeley and others. And they talk about many different factors that led to the creation of that.

The great things for California now is - there's a lot of people who have read that book by AnnaLee Saxenian and they're copying a lot of things that were traded accidentally in California. And my guess is in the coming years they're going to do a pretty good job at biting away at the edge that we have, because a lot of things that we have are not necessarily all that special. We can talk about an entrepreneurial culture, but at the same time there's a lot of hard feeds into that entrepreneurial culture. It's easy to talk about culture, but that's something that's hard to quantify and can easily be supplanted by someone else.

So, what we've been doing at LARTA is to try to figure out exactly how we can enable this process of innovation, of commercializing some of the basic R&D in California. And one of the things that we've done over the past few years is actually to develop a consortium. This is actually, we've been doing it quietly, but we have built up a consortium of 16 universities. Basically, every university in the southern half of California is now involved. Focused on the process of tech transfer. That is, trying to find basic R&D and trying to find new innovations and taking it out to the commercial markets. And we've gotten involved. Most of the major universities that you know of, many research institutions, large corporations, small businesses - and we found that one of the key roles that organizations that are not either industry or capital or research can play is in being an interface between all the others. By bridging information gaps and by pulling together resources that don't normally get pulled together, there is a strong role in being an objective arbiter of that type of bringing together. And so LARTA, in many ways, has become that resource within the broader tech industry.

One of our roles in D.C. was actually to go out and try to pull federal dollars back home, and we found that one of the key that folks kept asking us was, "Well, what is the state doing? LARTA is out here try to pull federal dollars home, you're trying to build these projects back in California, but what is the Governor's office doing and what is the Legislature doing?" And we tried to put on a good face, but there are times when, you know, we just have to be honest and say, "Look, there's not much money there and we're trying to do the best we can." But I think even without a lot of dollars there, there are thinks that can be done in terms of developing projects that help the people in California try to pull those federal dollars back. And keeping attuned to those types of issues and developing support mechanisms for folks like us who are trying to do that could be very useful.

I sort of talked about the innovation cycle and talked about a role in it, and talked about some of the different ways that organizations like ours can be useful. I'll bring you back to one example, when I was in D.C. on Friday, I got a copy of the newest study from the National Academies. The National Academies called in the trusted advisors to the nation's science and tech policy. In many ways it's kind of what LARTA tries to be, but more on the practitioner side in California. In that study, they actually talk a lot about Semitech and its role within

the semiconductor industry because it was a consortium with 14 of the largest semiconductor manufacturers, along with the federal government, focused on developing new innovations, but not really pure R&D. It was actually about manufacturing processes. It was focused on, specifically, how do you get higher quality, higher throughput in the manufacturing plants for semiconductors? And the analysis is very similar to some of things I've been talking about here, which is that those types of consortia have a very strong ability to help pull together information resources and overcome risks that would be too difficult for any one individual actor to take part in. And there's a way to pull people together, but pulling people together requires government action, it requires organizations that are viewed as being objective and government is probably first and foremost amongst those. So, the role for government has been talked about and it's been done before, and there's a strong role I think going forward, but it'll have to be, as Senator Bowen has said, to be done in creative ways.

Thank you.

VASCONCELLOS: Thank you very much - good advice. Thank you. Who is to be next? Sean?

SEAN RANDOLPH: Thank you very much, Heather, for the chance to be here today. I am representing the Bay Area Economic Forum, as well as the…

VASCONCELLOS: When each of you comes up to speak later on, just be sure you get a mike close so we can get it on the taping of this hearing and preserve it for our colleagues. Go ahead.

RANDOLPH: Great, thanks. Well, Senator, thank you for the chance to be here today. I am representing the Bay Area Economic Forum and the Bay Area Science and Innovation Consortium, or BASIC, which is a partnership of all the major government, universities, and many universal research labs in Northern California.

To get to the topic, California has for many, many years been seen as the first place where scientific and technological innovation takes place. And it's demonstrated its ability periodically over many, many years to continually reinvent itself to stay at the economic forefront. Well, we've had a lot of hand-ringing in recent years with the technology economy down about, well, the death of Silicon Valley and California falling off the map again. But when we look back over 30 years, we've succeeded repeatedly in moving our economy up to the next step. So we've innovated that technology; it's basically become commoditized. Anybody can do it - or they can do a lot of it. It moves overseas, it moves elsewhere, but we move on to the next level of sophistication value added.

Nanotechnology is something that we believe has the potential to help take California to that next level of innovation to keep us at the technological forefront. It really is a platform that applies in so many directions that can support our electronic sector, our biotech sector, the growing convergence in information technology and biotechnology that is more and more defining the products and the innovations we are seeing coming out of California and the Bay Area. And it has many applications also, unfortunately, a new field, which is Homeland Security.

So, economists are predicting within 10 or 15 years a trillion dollar economy for nanotech - who knows what the number is; it's going to be awfully large, however. But we are absolutely confident that California and the Bay Area have what is currently the world's preeminent R&D infrastructure that can actually get us to that point, at least in terms of basic research. Just to list the institutions that are on the case right now, we have the Molecular Foundry at Lawrence Berkeley Laboratory that breaks ground for their new center on January 30th. There's the Nanogeoscience Center at UC Berkeley. There's the NASA Ames Center for nanotechnology. There's the California Institute for Quantitative Biomedical Research, QB3, a multi-campus consortium in the Bay Area that includes the BioNanotechnology Center. There's Stanford's Nanofabrication Facility; Lawrence Livermore Lab's BioSecurity and Nanosciences Laboratory; and UC Davis' Nanomaterials in the Environment, Agriculture and Technology Program.

Well, that's a lot within about a 50 radius. And I think it's important to note that we are talking about nanotech now, but actually, very sophisticated nanotech research has been going on for more than a decade in the Bay Area, And the potential here is not just the presence of the R&D capacity at the basic level, but it's the juxtaposition with industry in Silicon Valley and in the region. We're looking at companies like, of course, SRI, IBM, Genentech, Kiron, Sun, Palo Alto Research Center - all right next door to these major research facilities, which really is something that, as we've seen in the past, is going to drive new product development and help it drive our economy.

It's also worth noting that consistent with Silicon Valley's history going many, many years' back, we're already starting to see some very significant start-ups in the nanotech field establishing early leadership roles for California. Companies like Nanosys, Nanomix, Quantum Dot, and Nanogram are already establishing a real presence in the field.

VASCONCELLOS: Quantum Duck? Quantum what?

RANDOLPH: Dot. Yes, Quantum Dot.

VASCONCELLOS: Dot?

RANDOLPH: D-O-T. Quantum Dot. And they're probably others out there we don't know about, but hopefully we will know about them soon.

So, we've heard already and I won't repeat all the different applications, but basically, they're in energy, biomedicine, drug delivery, materials, environment, computing, sensing (which includes Homeland Security). A lot of these are in the "gee whiz" category, but a lot are just over the horizon and when we look at companies like INTEL, they're already manufacturing at the nanoscale. And they're manufacturing - the future is going to progressively into the nanoscale. We're seeing things like chips - vision chips - that can actually correct macular degeneration in elderly people. Implanting carbon nanotubes. We're seeing nanocrystals that can eliminate or greatly reduce friction, which is really the enemy of almost any kind of machinery. We're seeing single molecule transistors on the horizon that could vastly increase computing-power with countless applications.

So, basically, what conclusions should we draw? Well, we are possibly at the threshold of a vast transformation in our technology economy with nanotechnology and its many applications as a platform for that. It's important that state and local leaders recognize that. That's why this hearing is so important.

Government funding is important. From the state level, and at some point and this is a really hard topic given the state's budget, the state will need to become a player. You need sometimes matching state funds for federal grants to get on to the field. We also need to focus our resources and attention on our priorities. You've already heard about Symantec. In the last decade California lost Symantec. We lost the National Earthquake Center to New York of all places, largely because we didn't have the focus as a state of what our priorities are to get these facilities here to California where they can be the most productive that they can be.

Finally, we do need to look at the issue of public leadership, local leadership; things like educational infrastructure that is identified in the CCST report. We need the workforce coming right up K through 12 and into the university system. We need to be supporting the development of new facilities and we need to have local government be part of this conversation because as already been mentioned. The quality of education, the building to get centers permitted, overcoming local opposition to development. The cost of housing, which makes it difficult for top quality researchers to mover here and live here and contribute. Those are all major issues that we need to address together, but we see tremendous potential from the standpoint of the Bay Area and Silicon Valley.

VASCONCELLOS: Thank you. Thank you, Mr. Randolph. I am pleased to welcome my colleague, Assemblyman Cogdill. We've begun, we waited until 1:15 p.m. and we got underway. We had the opening presentations about the big picture and the report from the Technology Council and we just started the panel that you were going to moderate. So if you want to take over, you can take over. If you look at the agenda before you there…

ASSEMBLYMEMBER DAVE COGDILL: I'm sure I do, Mr. Chairman. It'll probably take me a minute to find it, but I appreciate your…

We're ready to go to Daryl now?

VASCONCELLOS: Right.

DARYL HATANO: Good afternoon, Senator Vasconcellos and Assemblyman Cogdill.

Good afternoon, my name is Daryl Hatano and I'm the Vice President for Public Policy for the Semiconductor Industry Association.

Today I'd like to do two things. I'd like to talk about the importance of nanotechnology to our industry and also highlight certain parts of the CCST report of particular interest to us.

The semiconductor industry is America's largest manufacturing industry. We contribute more to GDP in this country than any other industry - 20 percent more to GDP than the next leading industry. Propelling the ever-growing semiconductor industry is the ever-shrinking transistor. The transistor is the

basic building block in a semiconductor chip. A decade ago, we put thousands of these transistors on each individual piece of silicon. Today we're able to put on millions and we're approaching the point where we can start to put on billions of transistors on each chip. Not only that, of course, we're making more and more chips around the world. So the net result is that we've got a tremendous increase in the amount of computing power that we're producing worldwide.

The way I'd like to demonstrate this is by telling you that in the time I flip this coin, we just produced some 60 billion transistors worldwide. That's a lot of computing power.

If I was invited back here…

VASCONCELLOS: Was that heads or tails? (laughter in the audience)

HATANO: If I was invited back here five years from now and did the same demonstration, I would say not 60 billion, but 600 billion. So we're increasing in order of magnitude every five years.

To integrate millions of transistors on each chip, the industry etches lines on those silicon chips down to a line-widths of about 50 nanometers. So to that extent, we're in the nanotechnology world already. However, the process that we're using, the device structure that we're using for these transistors, is basically the same device structure that we've been using for several decades - just a lot smaller. So, often people reserve the term "nanotechnology" in our industry to mean the new device structures that we'll be using in 10 or 15 years when we reach the physical limits of our current process - a point that Dr. Mayyappan, I think, mentioned in his presentation.

This is a key point in today's testimony. In 10 or 15 years, we will be reaching the physical limits of our current device technology and we don't have a replacement technology at this stage. So, the development of nanotechnology and the ability for us to have a timely replacement is critical, not only for the semiconductor industry, but also for the computer, communications, software industry, all the other industries that rely on semiconductors as one of the key driving technologies. We would need to have a commercial product ready in 10 to 15 years. That means not only do we have to have the ideas developed now, understand the physical properties of the nanotechnology that we're working with, but also make it manufactureable. And so, we've got a long ways to go between now and the 10 and 15 years in terms of the amount of effort that's required, not a lot of years to do it.

VASCONCELLOS: What's the single most important thing we can do to help?

HATANO: Fund university research. Most of the funding for university research is coming from federal government. We need California's congressional delegation to work together to help support that, and that's one of the key points of the CCST report, is the role of the California congressional delegation working together on this. I think Susan mentioned the importance of this to California universities and, I think it will be mentioned soon, the importance of California universities in all of this, but what I'd like to also stress is the role of California industry. That the benefits of nanotechnology isn't just the dollars going to our

universities, but the use of that technology by the high tech industry and California being the biggest beneficiary of that.

Second point I'd like to make highlights from the CCST report, is that it notes that 50 countries are working on nanotechnology development. And the point here is that this is not just a competition between California, Texas, and New York - two states in particular that are doing a lot of nanotechnology - but it's really a global race to develop nanotechnology. And perhaps more importantly, to develop nanotechnology to capture the manufacturing jobs that are going to flow from that.

COGDILL: Excuse me just a moment. How do we rank right now with the competitors that you just mentioned?

HATANO: I think we are leading.

COGDILL: Substantially or…

HATANO: Well, first of all, within semiconductors, the U.S. right now has a 50 percent market share and California is the leading state, I think, within semiconductors. Now as we move into nanotechnology, we're really talking about the research at this stage and I think we're getting a presentation soon that's going to quantify the importance of that for our universities. And basically, I think it comes out to one out of every five of the authors in nanotechnology are from California.

Another sign of that, I think, is the Focus Center Research Project, which is something that the semiconductor industry is co-funding with the Department of Defense. We have five Focus Centers in the United States that are looking at how do we find that new replacement? How do we get the technology so they're going to get us at that point when we run out of our current technologies? And also kind of the intermediate technologies, in between.

Of the 30 universities that are involved in these five centers, nine of them are based in California; and of the five league universities, two of them, Berkeley and UCLA, are here in California.

So, again, this is partly funded by the industry, partly funded by the government. And this is the sort of thing that to have the California Legislature also send a letter to, or - I'm not sure how/what the best way of communicating - you know, perhaps it's part of the communication of the CCST report. But, again, getting the California congressional delegation around that would be very helpful.

VASCONCELLOS: Is there _____ between you and Heather as to how this report gets to our California delegation?

HACKWOOD: Yes. We at CCST are trying how to get these communications to the California delegation. It would be very helpful to have some endorsement or proposal or comments from your committee to take to the California delegation. But we will…

VASCONCELLOS: Sure. Since we commissioned or asked you to do the report, I think we could certainly collaborate on a report to the delegation saying, "We commissioned this report. It's really precious. Be sure you read it and live up to it." We can put that on the cover of it. Okay David? Are you okay with that David?

COGDILL: Sure.

VASCONCELLOS: Okay. Good.

HATANO: The third item that I was going to highlight in the CCST report again gets back to what you were mentioning earlier in terms of the importance of preparing our students for this.

I mentioned earlier that in 10 to 15 years we're going to reach the physical limits of our current technologies. We need to have a replacement technology. The university graduate who is going to be working on that replacement technology in 10 to 15 years is in junior high school today and, obviously, that student we need to make sure is support and able to excel in math and science. And, obviously, there are a number of things that you're working on to do that. I certainly understand the difficulties in doing that in the current budget environment, but I think it's important to underscore within the context of the nanotechnology era the importance of those things.

VASCONCELLOS: If our keeping our leadership in this manically expanding future role depends upon having a highly educated workforce, we ought to figure out some way all of us here together to be sure that the schools get adequate funding so that the people get educated, graduated, and prepared to be the researchers and keep it here.

HATANO: Exactly. So, I guess to summarize, we want to keep leadership in nanotechnology not just for our universities, but for California high tech industries. It means recognizing that this is a global race, not just a competition among states. It means support university research and doing the right things in education.

Thank you.

COGDILL: Thank you, Mr. Hatano. Now we'll hear from Professor Darby.

PROFESSOR MICHAEL DARBY: Victor, if I could trade places with you. I'll like to…

Thank you. Thank you for having us. Thank you for being interested in the future. Too often political leaders are accused of being shortsighted, and this committee is certainly an indication of the best that the American political system has to offer in that.

BOWEN: Gee, you can come back anytime.

(laughter in the room)

COGDILL: We don't hear that often enough.

VASCONCELLOS: I think you're right.

DARBY: Okay, I'd like to set nanoscience and technology commercialization into a little more general framework. We've seen a lot of technological revolutions, a lot of rapid productivity growth, and one thing that characterizes that is that many are called, few are chosen. That relatively few firms and relatively few industries, at any given time, are actually making and applying the breakthroughs. I think that's important. It's often driven by some invention of a method of inventing. The Cohen-Voyer genetic engineering discovery drove Viatech. Before that, the double cross hybrid for seed, and we can go on and possibly scanning probe microscopy is the same thing for biotech. You've asked several times about the relative size. This is a measure of publishing. And we also have looked at the high impact, the very top articles.

This is for nano articles with authors at the top 112 research universities. The center at UCLA had this data. It mentions NanoBank.org, which is funded by a large interceptor and a million and a half dollars to build the nanotech system we'll soon have online data to extend what we know about nanotech and the research in the field, as well at the industry.

So far we know that Los Angeles/Santa Barbara really the large region between north of San Diego and south of about San Luis Obispo, is number one, with San Francisco Bay Area a close second in the U.S. Now, it's not unusual for San Francisco Bay and Boston to be at the lead of major technological revolution. What's unusual is that LA and the Southern California area is carrying its weight on this one.

VASCONCELLOS: That's revolutionary.

(laughter)

DARBY: Yes. We checked the data twice. It's just amazing.

We've done some preliminary research on where and when firms are entering nanotechnology. And sort of the two biggest lessons are it's where and when highly cited nano articles have recently been authored by faculty at universities receiving large federal research funding and where the skill levels of the labor force are high.

The size measure that matters for the region is not the overall employment, but the size of academic S&E base. I think that's an important research finding.

We can look at the firm growth by region, or firm entry by region, and New York City comes in strong. Partially that is reflecting that New York state has very strong program. Texas has not done as well, so far, although they are certainly coming on strong, so that may change in the future. But San Francisco and Los Angeles continue to be up near the top, with Boston fourth. You know, these are just a number of firms actually doing research, not necessary weighted by employment which can make a big difference, but we just don't have that data yet.

One thing that's important to note is this is all nano articles published by California firms from 1985, which is probably about when it began, through 1999. And the blue segment at the bottom, purplish-blue anyway, is the number of those articles that not only are published by firms, but also have co-authors at the major research universities. In California those are the nine campuses of the University of California, CalTech, Stanford, and USC. And as you can see, we have, not only an upward trend in the percentage of those articles, but also a fairly substantial that's now averaging around 40 percent of the research done in firms and published as actually cooperatives with our university scientists.

Now, part of that may be the other way around. One of the main findings in the research project that Professor Zucker and I have been engaged in for 15 years now is that typically the great research universities draw in great faculty, retain great faculty, some of whom are entrepreneurial. Some of whom get involved with firms and that third or so are the ones that are the gooses that, if you will, lay the golden eggs for the semiconductor industry and others. And so part of it is keeping those folks there. We're better positioned that we were, even in early biotech. Although we didn't have the enabling discovery, the

microscopy. That was actually done by IBM in Switzerland. In terms of the people who have been using it and using it well, they're all over California. That's certainly unusual. We have a highly skilled population, which believes in growth, progress, and the future, that's great. We got these problems: Top universities' faculty role in firm formation means that we've got to keep those faculty. We've got to do something to encourage the universities to view technology licensing from the point of view of the state in terms of economic development, not just as a source of revenue for the university, which sometimes can be at cross purposes.

Roughly 70 percent nationally of the university inventions that are ever licensed could not have been licensed if the faculty did not cooperate with the firms in transferring that passive knowledge. So that's, I think, an important role for the universities. Also, and obviously, the Texas tax and regulatory climate, so far, is, I think, very favorable. But I think with the budget situation, that too is in danger.

And that's what I had to say.

COGDILL: Okay. Thank you very much.

We've talked about the dollars involved here and the need to continue the support. Do you have any of that information as it relates to what's been spent over the last few years in this area from the university standpoint and what…?

DARBY: Well, in the report there's a pretty detailed analysis where now, we've already nationally spent close to a billion dollars and we're engaged in a 2.5 - 6.7 billion dollars new program at the federal level. Part of the problem which people have alluded to is getting the state support and also the congressional delegation. The UCLA-led team for it to be the - for the National Nanotechnology Initiative - the National Nanotechnology Infrastructure Network, was one of the two finalists. The New York congressional delegation was very strong to keep it at Cornell and ultimately, I think that that may have, you know, that if we'd had stronger support from the California delegation. But you also go to these places like Texas where you, I was born in Texas so I remember trying to find a university in Texas that was decent. And now you see Rice, Texas A&M. University of Texas at Arlington, which used to be sort of just a step up from a community college, now has four nanotech buildings. I mean it's just incredible what some these states are doing in terms of matching federal grants and what California can do with it, I don't know - our budget, but is an issue.

Let me trade with Jose so that…

COGDILL: Well, just hold off on that. I was just wondering. Is there any opportunity for the California taxpayer to be somewhat of a venture capitalist in all of this so that - other than just putting the money to continue to fund it - and then, at some point it obviously starts to create substantial returns to our society. Is there any way for the taxpayer to actually be, either paid back or to have these dollars returned to the system so that there's some accounting for the monies that the state puts up in advance, so to speak, to further these studies?

DARBY: I think that the licensing, often the basic research is done in the university and if the licensing is done efficiently, the university gets back, as we did with say the Cohen-Boyer. So I think that's sort of the return on the state's

investment, actually we have a system with the Bayh-Dole Act in place. You know, the federal dollars really don't get returned, other than in federal income taxes with the greater groth.

COGDILL: That's really what I'm looking for here given the constraints that we have with our budget right now, is to look for some way to be able to justify in these times to continue to support this. And I think that would be a way to do it if we could say, "this is up front capital that we believe makes a lot of sense to keep us on the cutting edge and to move forward and there is this very strong promise that this money will be returned to the people of the state."

BOWEN: But we do that through the CalPERS investments, I believe. And we have a CalPERS fund that invests in some of these things, and that, obviously, has been successful in reducing the obligation of the taxpayers. So I think the difficulty is that the return doesn't come in directly, it comes in in a reduction in the obligations to fund the university or to fund the…

DARBY: The California Nanosystems Institute, I think, is engaged in a lot of university-industry research where the funding is coming from industry over time. And we also have a similar thing with the Industry-University Cooperative Research Program where we actually get industry to put up substantial funds for basic research that's relevant to them. I think those are very good industry-government partnerships.

COGDILL: Okay. Dr. Stetter.

DR. JOSEPH STETTER: I want to thank you very much for the opportunity to address your committee today. As you can see, I was told to put together some thoughts and they're pretty eclectic - entrepreneurship, business, transit and nanotech in California. And I'm on a leave of absence from Illinois Institute of Technology, but I did buy a house here in California, I voted in the last election, and I'm here for one year, and I'm staying for a second year. So, I consider myself a new Californian and maybe that gives me a unique kind of perspective because I'm also an entrepreneur. I came originally to be VP of Engineering at NOMEX where I put together their engineering team and we put together the first nanotechnology-sensing device, which is going to be in beta test. I since left there and I am president of Transducer Technology. And although the company is in Chicago, I brought a portion of it out here to the Bay Area, specifically because of the high tech infrastructure that's here to collaborate with a local company in Newark, California and develop some nanotechnology and mems for bio and chem-sensing. However, you know, while I read in the paper on the weekend that Governor Schwartzenegger was looking incentives to get Virgin, what was it, Virgin Airlines? Virgin Airlines to move to San Francisco, I still haven't found any incentives to move m y company here. Now I brought part of it to collaborate with the technology here, but there's not a lot of incentive for me to bring it all here and keep it with the costs of moving it here.

COGDILL: I think we can get you an appointment today.

STETTER: Anyway, I'm here representing the individual. I really don't have an organization to represent, and as an individual, I see business trends. This is something I came across in my travels. A 1991 Nobel Laureate in Economics really put it simply - and this is really kind of back to the basics - what drives

business structure and the cost of transactions, there's really only two alternatives; person to person or entity to entity selling and organization to person, organization to another entity. And with modern communications and the technology like we do in the Bay Area here, the cost of number one drop substantially. Internet. Person to person is becoming big. And what effect this has on organizations and corporations, from labor unions to large corporations, is they're going to shrink in size, or at least they're going to become multi-locational. They're going to become flatter, as you saw in the 90s. The middle management disappeared. And we're going to outsource R&D. Recently I read an article that the CEO that left GE, Bob Welsh, had a 70-70-70 percent rule. Seventy percent of his research and development was going to outsourced, 70 percent was going to be overseas, and 70 percent of that was going to be in India. And that's just to give you an idea of what intellectuals are thinking these days and the trend will not slow down, but accelerate.

So, what to do about this kind of stuff? Successful partnerships meet the needs of all parties - and this is, so there's four. I was at a symposium, the International Forum on Process Analytical Chemistry, just two weeks ago in Washington, D.C., and I was a plenary speaker on the program with ex-Congressman Bob Walker from Pennsylvania. And he brought this up, he said this here is what you've got to work on: government-business, government-academia, the government has two independent associations to foster, and then you have to make an environment for the other two - academia-business and business-business. And that's where you should focus and to give it any meaning, it has to be some kind of sustained or continuously evolving effort. If you don't keep at it or your just put some spurt on it, it doesn't work as well.

Where is the future for California? Information, in my mind, is power in the 21st century and at the bottom I put an example of what I am doing here in the Bay Area. My company, TTI uses plastic from India, tips from Singapore, nanotech that I brought from Chicago, polymers from Virginia, and California is giving me the mems-seamoss integration that I need into the modern technology. And so if you are a power base, or you are going to create a power base, it's going to be an information base and you're going to have to draw from all over the world and the internet allows individuals to do that, or entrepreneurs to do that.

BOWEN: Where are your mems coming from?

STETTER: Well, I do prototyping like at UC Berkeley Lab right now and I have a foundry, a partner, an industrial one in Milpitas that's helping me with some structures.

BOWEN: That's good enough. We're trying to get sort of a picture that's a combination of big picture and then sort of some examples of it and that's helpful. Thank you.

STETTER: So what I need as an individual, an entrepreneur, we need to be encouraged, but not staged. Okay, some things need to be staged. In other words, where can you get housing? That's something that you have to stage because it's got to be in some place. But mostly, just decrease my paperwork, decrease cash flow, and decrease my risk. And the SBIR Program does that. That's my only foray, I should say, into legislation. I helped Congressman

LaFalsa's staffers write the SSTR legislation when it was piggybacking on the SBIR in the early 90s.

So, I am familiar with how to put incentives in the system to do that. And this is something that I've always wanted government to do more of me, is level the playing field. You know as a small company, where do you get health care for your employees to attract and keep them? Where do you get incentives to move in? And healthcare is a good example because everywhere the government has an IRS worker or has a postal worker or any government worker you have a professionally negotiated plan and that just needs to be made available to everyone. We don't need a new plan or a new bureaucracy, necessarily. But that levels the playing field and helps you compete and get your business going.

Okay, so this was Bob Walker's suggestion for industry does productization, the brand of research. The government does basic R&D, and that's where their funds go. And I put this word in there - "the misunderstood valley of death" - and the reason I that is this is between products and research. It's misunderstood because if we understood it, we could do it better. I think really that's a place if you're going to do some understanding, and some of the universities could help us in this valley of death that's trying to understand that and one of their major mistakes is confusing technology development with product development. They're two different things. Universities primarily do technology development, companies do product development.

Fund research in the public interest, which is kind of a no-brainer, but there are things that business won't fund because it's not in their interests.

Most innovation comes from small firms, and my motto is "if they get SBIs, give them awards and help them get more."

Here's something that's controversial, "don't push the wave of the future." People are telling you to push nanotech. I think of it rather as "fund the best ideas and let the future be your teacher." And nanotech is a technology, not really an industry. And we need to know that it enables a lot of things and necessarily is important to us, but not necessarily as a technology industry.

And see it from the entrepreneur's perspective. We all want to be very successful like California. What we fear are instantaneous disasters. What we get is usually a roller coaster, and we view success when we get a successful company or something as something that we catch and it makes us feel young again. And I think if that in mind, you will write legislation from the entrepreneur's perspective.

Thanks.

COGDILL: Thank you. Any questions from the panel? Senator Bowen.

BOWEN: I actually would like to explore, just for a second, your suggestion that - and obviously, we can't make the Federal health plan available to your employees. We'd make it available to ourselves, I think, if we could. That instantly made me think, well, we do have, certainly, State health plans available in various places, although we're facing the same escalating costs as the private sector is. But the concept of aggregating or making available health coverage that already exists is an interesting one. The question, I mean I don't know how much you thought about it, but what kind of resistance do you think we would get

from the health plans who would rather sell you a more expensive plan for your small business?

STETTER: Well, my plans for IIT cost me about two or three hundred dollars a month and if I wanted to go out and buy that, it would be about $1,000 or $l,l00. So going out with your own company, it's obviously a burden and you need to be connected to something or somewhere and that's a big help. I think I that, from the state's point of view, they're now - with prescription medication purchase, this, of course controversial, I think this would be another one that might be controversial. But you could put the risky people in a risk pool, like you do with auto insurance and things like that.

BOWEN: We actually have a risk pool.

STETTER: And I think that it should be palatable. They should get a lot more people on the roles and companies that can afford it should pay and companies that maybe can't afford it should get a break.

BOWEN: Interesting thought to explore. Let's see what might come of it - worth exploring. Thank you.

COGDILL: We have a little more time with this panel. I think at this point we'd just like to open it up, if there are any questions from the audience? Anyone that would like to ask a question, make a statement? You've got about five minutes. Please step forward.

JIM HURD of the Nanoscience Exchange. I just wanted to ask the panel how they perceive California U.S. Senators as being involved in the process of staying competitive? I think we've seen leadership from a number of U.S. Senators, and I think we could use a little bit more participation in the very competitive areas. I just wanted to ask your opinion on that.

COGDILL: Gentlemen?

STETTER : I think they've been very successful. You can see by all of the R&D funding that comes here, and the Nano Initiative, and they got the first homeland security center at Southern Cal. So, I think that California competes very well. Whether it's as good as they should, or other things, I don't know. But that's one of the reasons I'm here, also.

HATANO: Last week I actually sat down with Congresswoman Jane Harman's office because we're specifically working on an idea potentially developing a technology commercialization center focused on homeland security in Southern California. And what I found, it was interesting, is that you would think that California has very active role in trying to bring a lot of this stuff back to California because of some of the successes, especially on the research side. But what I discovered was that they actually are very responsive to what people are bring forth to them. Because there are so many issues that they are dealing with, a lot of which are more national in scope, that thinking about specific technology development issues back in the home land is something that they almost need people to kind of come at them with ideas and proposals for. Believe it or not, no one had really approached her office before about trying to do a project like this. And my guess is that there's probably a lot of opportunity for it if folks would actually take the initiate to go out and put in the legwork to try to develop projects like this. I think in nanotech there is a lot of room. California,

while it has been successful in certain places, it has actually lost out on a few major nano proposals out there Both on the NNIN that was talked about earlier, as well as some centers of excellence that were given out last. California actually didn't get any of them because it's become a process that's been driven a lot by people in certain circles in Washington. So, there's a lot of things we can do here.

BOWEN: I really want to highlight that because I think California has 34-35 million people now - Wyoming, which has a population of, I believe of, fewer than 860,000 - still has two U.S. Senators. So, if you think about what happens, an industry or someone with an idea in Wyoming is very likely to get a whole lot more attention than some one in California. And the amount of legwork or staff time that you have available to go look for things is a whole lot less when you're trying to deal with that many people. That's certainly true of us in this building, too. Senators here have just huge districts compared to any other state. And I know this is going out on the California Channel, I really want to emphasize the importance of communication that comes from people with good ideas and thoughts because very often we are stuck here in our hearings and we may do something like this. But there a lot of people out there who have creative ideas, who have projects that only get off the ground if they e-mail or make a phone call or whatever, and now comes the commercial - I believe that there is a website of this Committee. Right? And anybody who has something to say who is not here today, is certainly welcome to e-mail us. You can find all of us who are here on the Committee at the Senate's website at www.sen.ca.gov or just go to the California government website and Google will help you find any of those without knowing… We really depend on people coming forward. We can help, but as I said before, none of us here, none of us have Ph.D.s and none of us are specialists in technology and we really need to hear what the needs are before we can help carry the ball. So, I think that's a really excellent point, and we have a competitive disadvantage compared to smaller states because we are so large and so diverse. So we need more, even than the smaller states to hear from people of what's needed.

HATANO: I guess what I would also add to that is the importance of our delegation working together because we do have the largest delegation, but we're not as cohesive as some of the other state delegations. We do have some people very well placed in the right appropriations committees. We need to ask the delegation and make sure that they're supported.

COGDILL: I know the Governor has made a point of talking about bringing together the delegation and doing what he can to lead them as it relates to certain issues affecting Californians. So this might be a good opportunity to be sure that his office and his administration is up to date on what we're trying to do here.

BOWEN: It's a really good year to do that, too, because we know we're going to have an effort on military base retention. And one of the biggest R&D centers is at the Los Angeles Air Force Base, which just happens to be in the 28th Senate District, and it's an R&D center for the military. So we're going to be asking the delegation to come together to support us in keeping our military bases and, of course, especially the LA Air Force Base because the multiplier

effect of all of that R&D throughout the state, particularly in the LA Basin. But we'll have the congressional delegation together, I hope, around that issue and the Governor has taken a leadership role already in that. So, it's a good time to hitch on to that kind of cooperation and work on our other tech issues and economic development issues.

RANDOLPH : I would support, Senator, what Daryl just said about the California delegation, despite its size, it really does not have terrific record of working together in the past. We've lost some big fish in the past. If you look, for example, at the Federal Formula Funding Grants where you mentioned Wyoming, per capita we get a fraction of what Wyoming does. We're seeing that in homeland security. I think the Public Policy Institute of California has a new report just out that talks about how that impacts us here in California. But I think in a way, although we've done well historically getting federal research dollars, we started a political deficit because California is sort of the "big gorilla" and there's kind of a big disinclination to give money to California. Like, "aw, California's going to get it all," and so I think, in a way, we have to work harder. I think we can make the best economic case that the dollars invested here will be used the most efficiently. We have the best base for investing and turning those things into things that support the economy - probably much better than any other part of the country. But, again, we're in a political deficit in Washington. We have to work harder to get those dollars and we have to work together to do that.

COGDILL: Point well taken. I want to thank the panel for your presentations. It was very, very informative. We're going to take a short break now, about five minutes or so, and when we come back, Assemblymember Hannah-Beth Jackson will be moderating the next panel. See you all in about five minutes.

ASSEMBLYMEMBER HANNAH-BETH JACKSON: We're almost on time. Can we have everybody take their seats, please? And if we could have the next panelists please come forward. They are Robert Haddon, Christine Peterson, John Miller, and Anthony Waitz. Good afternoon.

I'd like to introduce myself. I am Hannah-Beth Jackson, Assemblymember; I represent the 35th Assembly District, which includes the University of California at Santa Barbara where we have broken ground for our new nano center. A huge, beautiful building that we're going to be building there. So I have, also, a particular interest in the success of this endeavor.

We're about to talk about the environmental, ethics, legal, social - all those non kind of economic technological aspects. But important, in fact, extremely important nonetheless. So what I wanted to do is start this off by reading something I saw in the paper yesterday, which I think really encapsulates the reason and the need for this pursuit to go along in parallel with the actual technologies. And it goes:

> **"The means by which we live have outdistanced the ends for which we live. Our scientific power has outrun our spiritual power. We have guided missiles, and misguided men."**

And that was a quote by Martin Luther King in 1963.

And so with that, I'd like to invite our first speaker, Mr. Haddon, to introduce yourself and go ahead and give us your presentation.

ROBERT HADDON: Hi. (problems with the mike) It's a very difficult size, actually. I guess it's a little too "nano." I guess I'll just hold it.

My name is Robert Haddon. I'm the Director of the Center for Nanoscience and Engineering at the University of California at Riverside and I'd like to thank the Committee for the opportunity to talk to you.

This is actually my first time talking about the social and ethically impacts of nanotechnology. I'm actually carrying water for Susan Hackwood in this respect and I'm getting a little nervous because I see that Susan has already left the building. So if there are any tough questions, we may have to turn to the other members of the panel to answer them. But the reasons I am interested in the social and ethical impacts of technology are three-fold, I think.

The first is that any technology, any really new and powerful technology is inherently disruptive. And so, there are going to be large impacts as nanotechnology works its way from a research specialty to a technology into the commercial market place.

So, it really behooves us to think about what is going to happen. What is going to happen beyond the research enterprise as nanotechnology establishes itself? And the social and ethical impacts are going to be very large. Now, one of the reasons that I've become interested in this is that we are proposing to develop a center - which I'll talk to you a little bit about toward the end of my talk - and Susan Hackwood, the Executive Director of the CCST, is going to be leading our effort within our center and we hope to fully understand and try to anticipate some of these impacts. And, of course, we hope that Susan will involve the members of this Committee as our center goes forward with this research program and, in fact, as we examine the social and ethical impacts of nanotechnology.

Now as I have already mentioned, I think the social, ethical, and environmental implications of nanotechnology are going to be huge. We can't, of course, foresee all of these, but I think we have a responsibility to the public to try to anticipate some of these. And this, in fact, has been recognized in the National Nanotechnology Initiative. Furthermore, despite the availability of quite a large amount of federal money, there really has been a deficiency in the research proposals that have been received to address these issues. And, in fact, we think that our research proposal will be a pioneering contribution in this area.

Part of the challenge, of course, is that nanotechnology is not just one thing, it is many things. The way I like to look at nanotechnology is that it is really the meeting place for the scientific and engineering disciplines because finally with nanotechnology, we get down to the very building blocks of matter - atoms and molecules. And so finally, the sciences and engineering disciplines are talking about the same thing. Atoms and molecules, it doesn't make any difference if you're an engineer, a chemist, or if you're doing medicine. You are thinking about the same basic building blocks if we are working with nanotechnology.

What are the problems we might realistically expect to address? Obviously, the environment and health risks have to be prime. We are charged with safeguarding the health and wellbeing of the citizens of California, the country and the rest of the world. Security and terrorism, of course, are high on anyone's list right now. That goes without saying. Anything that can be made small, that is powerful, clearly could be subject to misuse.

There are going to be large shifts in the economy.

The supremacy of industries: There is no doubt that industries will fall away. Some industries will be successful at the expense of others. There will be displacement of the workers in these industries. The necessity to make sure we train the workforce in technologies which are not simply dead ends.

Privacy: There will be the opportunity for new types of sensors, ways to detect, ways to measure, ways to incurred on a far smaller and more invasive scale than has ever been possible before. This, of course, will be useful to security and terrorism.

Cultural, moral, and philosophical aspects beyond those we can imagine: The degree of communication, the power of the computation that will be available in the future will simply dwarf what has happened up until now. We have to address unrealistic fears early. You've only got to look at biotechnology to see what can happen if we don't speak to these issues early. When I give general talks on nanotechnology, I am always asked about the book "PREY" by Michael Crichton - always asked about this. People literally accept this stuff, that there's going to be nanorobots running around in our bloodstreams. Okay, this is straight out of - what was that movie? Fantastic Voyage. And who starred it? Anyone know? Raquel Welch. All right, thank you.

What do we need to do in California? We need to adapt. We've got to be adaptable. We've got to be flexible. This applies to all aspects of our environment from the government to the universities to the industries to our workforce. We've got to conduct a realistic analysis of the situation with out hysteria, but with due concern for events we may not be able to control. We need a core base of interdisciplinary knowledge with work by both social scientists and scientists who are working at the forefront of this new discipline. We need case studies; we need to be neutral, objective, and scientific. We need to incorporate the appropriate remedies and we're here to establish a dialog with the public and policymakers, such as yourselves. And we hope that you will stay involved in what we're doing.

Finally, I want to talk a little about the proposal that we are writing to the federal government. People have asked about California's ability to secure federal funding for research in nanotechnology. So I want to just say a little bit about this proposal that we're writing. It's a joint effort between UC Riverside, UCLA, UC Irvine and the University of Florida. We got passed the pre-proposal stage; we're now writing a full proposal; it's on carbon nanotech devices and circuits. We are partnered with INTEL. We are partnered with Tesera. We are partnered with Nanomix. We are partnered with Carbon Solutions. We are partnered with NASA Ames. We are partnered with JPL in Pasadena. All of these companies, all of these universities, except Florida, are in California. So this is a

solidly California-based effort in nanotechnology. It includes a very strong program on the environmental, economic, societal and ethical impacts of nanotechnology, which will be lead by Dr. Susan Hackwood, the Executive Director of the California Council of Science and Technology.

So, I think that speaks for itself; that this center will not combine cutting edge research in nanoelectronic circuitry, but will at the same time, involve the California Council of Science and Technology directly on the societal impacts and, hopefully, the Legislative Branch as well.

So, I think I'll conclude there. Should I take questions now or at the end?

JACKSON: I'd like to wait till the end so we can make sure everybody gets to speak. I've been told, I though we had all afternoon, but apparently we only had 35-40 minutes for the panel. So, if we could go on to the next speaker, and I'd like to ask if you could try to hold your comments to about five minutes and that will give us, five minutes each, and they will give us a chance to get a few questions. Maybe we can sneak a minute or two from the break and go from there.

And our next speaker, I apologize, I didn't introduce you Dr. or Professor Haddon. Professor Haddon had been involved, actually, in the work and the preparation of the work that's been done here so far. Thank you very much.

Next we have Christine Peterson and she writes and lectures and does all sorts of wonderful work, but most importantly, she's a graduate of MIT and I assume, a Red Sox fan. Good. With that queue having been well taken, I'll go ahead and ask you to speak.

CHRISTINE PATERSON: Thank you. No matter where I stand, I'm going to be… Okay. Great.

Nanotechnology is kind of hard to understand it's such a big field. So I'm going to simplify it radically for a moment and divide it into three basic areas: nanomaterials, nanoelectronics and nanomachines.

We've heard quite a bit about the first two and I think the report does a great job of addressing them. The nanomachine area, I think, is one that we can do more work on. So I'm going to a five-minute crash program on nanomachines.

The term is used many different ways. You notice the second one from NSF, work at the molecular level, atom by atom, to create fundamentally new molecular organization. When they say "atom by atom," they don't mean you pick them up individually, and put them down. That's not how atoms like to work. Think of that as being atomic precision.

You see number three, the meaning "nanomachines." This is the area we're going to look at now. It is a long-term area. I'm going to try to make the case that it's a particular strength for California. Even though it's long-term, we can positions ourselves to be, I think, the world leader for some indefinite period of time.

Why is this? Well, we started it all back in 1959 with Richard Feynman of CalTech, who gave an incredibly visionary talk called "There's Plenty of Room at the Bottom." Earlier someone called for a coherent vision of nanotechnology; I'd say go to the web, type in "There's Plenty of Room at the Bottom," there it is. He

had it there. Nobody should be surprised that Richard Feynman had it right, even that early.

This is also termed "molecular manufacturing." It's new way to think about matter. We heard earlier today the terms "top down" and "bottom up." We want to building with atomic precision from the bottom up. Today we can build large complex structures, or we can build with atomic precision, chemists do that all the time. We to do them both at the same time. We want to build large complex structures that are also atomically precise. What will this give us? Direct control down to the molecular level. You can just imagine what this would mean for medicine. I'm not going to cover that today. It is hinted at in the report. There is a projection, I believe it's credited to Dr. Haddon, of medical devices of this type in 15 years. That's on page 15, I think.

So, how do you do this? Well, you use molecular machines, nanoscale machines. Is this an analogy? No. We're talking actual machines. How do we know they can exist? Well, biology illustrates molecular machines, including nanomotors. They're actually found in nature now. So, if they exist in nature, someday we should be able to building new ones. Seems plausible, and there's software today we can use to design these things. You can design them, you can run them, and test them to try to project what will be possible in the future.

Here's an example: You have a differential gear in your car, so I'm told. I'm no car expert, but that's what I'm told. Here's a cutaway view of a nanoscale differential gear. Now this is not an artist's conception. This one and the next two are not artists' conceptions. They are done with the best chemical software that is available today. These are real designs. Can we build they today? Absolutely not, this is long term. In fact, one of the best ways to scare economists is to say, "There, that's your job." It's terrifying to them, and rightly so.

This would be the tip of a manipulator arm. This would position a tool. And again, a real design.

Here we have a bearing model. You see it is actually moving there, just as a real bearing needs to do.

Now what would you build with they things? Why bother? Well, what we need, obviously, is a factory. We need a nanofactory to build things.

This shows parallelism. Now you've heard and you'll see in the report the term "self-replicating." That is totally different from parallelism. If you want to build some that is big and start at the nanoscale, you've got to have parallelism. You've got to have a lot of machines working together. You do not self-replication, which is making copies of the same machine. So these are totally different concepts. We use parallelism all the time in our factories. We can do it at the nanoscale.

Why machines? Well, materials and sensors and electronics are great, but this is how you could make them better. You could make all these things better. What's most important to me as somebody who cares about the environment is this would be an incredibly clean way to build things. You don't have a lot of leftover atoms and molecules to throw into the air and the water. They're all under complete control.

Is this plausible? Well, these kinds of medical devices are mentioned in our State report. They are also mentioned here in the NNI federal budget for 2004 machines as small as human cells.

Is this visionary stuff? Yeah, it is. But that's okay. California, hey, this is where the future is made. Right?

So this changes how you work with physical matter. With the environment you could end chemical pollution, do thorough remediation of the messes we've already made. For medicine. The intercellular machines of our report. And there is a down side, as always, with powerful technologies. You can imagine pretty scary military applications.

So the report for today, great job on materials and electronics. We do need to work harder on the nanomachine angle. We hear about the self-replicating nanobots way too much. Let's put aside the Michael Crichton senario. Enough already with that.

California has huge strengths and design in systems engineering and software. Those are critical for this project. We could win big on this one. There's been a suggestion in the report that we have a Nanotechnology Research and Workforce Advisory Council. That's a great idea. I hope it's funded given the budgetary situation. I don't know if that will happen, but we already have a very good California Nanosystems Institute and if this advisory council is not funded, I was just told by someone from the budget office that the CNSI is still funded. So, we could use that existing resource to step-up our work in this area.

Thank you.

JACKSON: Thank you very much. That was just about five minutes. Thank you. I hope it didn't force you to rush too much. Again, there will be an opportunity for questions if we can keep it to about five minutes. Our next speaker is John Miller, who is the Managing Editor for the Nanotechnology Law and Business Magazine, and started off as a lawyer. That'd be an interesting conversation that, obviously, you got smart and decided to go into something else. We're glad you're here and glad you're doing what you're doing. So go ahead and give us your presentation. Thank you Mr. Miller.

JOHN MILLER: In addition to my role and the Managing Editor of the Journal, I am also involved in what has now become an extremely long book about nanotechnology law, policy, and business issues that will be published in the Spring of this year. So, I kind of want to talk about some major themes that we conclude in the nanotechnology policy section of the book.

The first is that nanotechnology will pose a variety of safety and ethical issues. And it's interesting that in the book we divide the field into categories similar to Ms. Peterson did, which is one, is simple technology, which primarily includes materials applications. The chart in Table 5-1 of the report are examples of some of those applications. Those are things that are going to occur in the near term in the next few years.

The second category is Building Small Nanotechnology, which involves precise positioning, fabrication, and manipulating nanomaterials and nanostructures for devices and systems. Examples of this are integrated circuits

and more advanced energy devices, drug delivery mechanisms, things that we probably won't see for the next five to 15 years.

And the third category what we call Building Large Nanotechnology, which is what was just explained in the last presentation. It's molecular manufacturing.

There are different ethical and safety issues that accompany each type of nanotechnology. Simple nanotechnology, there is not really any ethical issues as it is primarily just improving existing materials. But there are definite legitimate safety concerns involving toxicity issues associated with nanomaterials. And in the book, we go through and kind of deconstruct all the different studies that have taken place recently involving nanomaterials and their toxic effects and conclude that, really, there is no certainty and there are no answers at this point. And that it's field that will require an increased study and investigation to determine what the toxic effects are.

Building small nanotechnology, the real ethical issues involve things related to whether or not we want to have computer processing power that provides capabilities similar to human intelligence. Do we really want more advanced drugs that allow us to detect genetic diseases early on? And, as the report explains, there are huge privacy issues associated with microscopic sensors. And building large nanotechnology, as Ms. Peterson noted, I think is problematic in that that's where the real ethical debate against nanoscience is going to take place. And it's a misguided debate, but when you have things like the PREY book and Bill Joy screaming the potential for extinction with self-replicating nanorobots, it can cause a public frenzy. So, we think that there needs to be kind of a demystification of what molecular manufacturing is about and how we can develop policies that safely guide us in a way that doesn't incur the harms that have been discussed.

There are two comments that I want to make about the safety and ethical issues. One is that we conclude in the book after rigorous policy analysis in which we engage a lot of risk assessment and cost benefit analysis that the risks pale in comparison to the benefits. So it's definitely a worthy endeavor and we should continue to pursue nanoscience and its various applications.

Second is; in reading the recommendations in the report, I think they are extremely useful in educating the public about the different safety and ethical issues, and I want to kind of suggest one other idea that Tom Kaleil has brought up. He was instrumental in promulgating the National Nanotechnology Initiative for President Clinton in 2000. He suggested that, in addition to things like the nanoethic centers and the curriculum in schools that we have, we have a huge state or national effort to explain nanotechnology on big IMAX screens to education not only students, but also the general public about its potential and its implications.

The second broad theme is that nanotechnology will pose complicated legal and regulatory issues, and I think there are three really good examples of this that we point out. First is at the Patent and Trademark Office. This is, I fear, is the one area where the law can really frustrate development of the technology in that the Patent and Trademark Office has not done a good job of preparing to review nanotechnology patent applications. And as a result of their ill

preparation and the obsessive compulsion to patent anything and everything in this field, there are broad overlapping patents on sometimes several dozen, on similar technologies. And the risk is that when companies go to commercialize their products, they're going to become embroiled in intellectual property disputes, which will only make lawyers wealthy, but will not be good for progress in the technology.

The second area or the second kind of legal regulatory issue that we explore is the Environmental Protection Agency. There are laws that regulate new chemicals and because nanotechnology primarily involves scaling-down the size of existing chemicals, these new nanomaterials are entering the environment without any regulatory review. For example, carbon has already been proved under the Toxic Substance and Control Act. Now carbon nanotubes, which have wholly unique properties because of their size, are entering the environment without having to go through any regulatory review procedures.

And the third area is at the Food and Drug Administration. I think a good example of difficulties that the FDA will encounter in regulating nanomedical products are where an existing drug has already been approved by the FDA and a company develops a novel drug delivery mechanism based on nanotechnology. And the question will be what amount of clinical data and evidence is required for the company to prove that the drug delivery mechanism is safe with the already-approved version of the drug?

So, these are huge complicated issues that the federal government has to work out, the federal agencies have to think through, and they've started to make some progress, but I think there's still a long way to go in being proactive, rather than reactive.

I think I'm getting a little short of time, so the third area I'll kind of summarize as funding issues, and this will probably be talked about extensively in the next panel, as well. Our conclusion is that to the extent that the state does find nanotechnology research and development, it should focus on research areas that are high risk, long-term, and interdisciplinary and avoid funding more near-term commercial research and development.

I'll conclude with that.

JACKSON: Thank you. When you do - if we do have a moment, the question I'd like to know is what do you recommend in terms of - you identified some the problems the federal government is having in addressing the future expectations of patents and so forth, if you have any suggestions. That might be helpful, if we have time.

Next, we have Anthony Waitz who has 18 years experience in technology development, management, and strategy, and he's going to close out our panel and hopefully, in about five minutes, and that, too, will give us a little time for questions.

Thank you and welcome Mr. Waitz.

ANTHONY WAITZ: Thank you. I'm going to sit down since I'm just too tall to bend over and lift this mike up.

Well, when I was asked to do this, I was told I should focus on IP issues and I was a little bit uneasy. You know, my background is in Engineering and

Business, so talking about what legal issues - well, we just had a lawyer talk about social and ethical issues, so I feel better now.

So really, my prepared slides are just really focused on IP and you may ask - why should you believe me in talking about IP? What do I know about it, given my disclosure about my background? My firm, Quantum Insight, is a consulting firm and we have worked with VCs, Fortune 500s, and start-up clients. And so we - for VC we looked at over a hundred nano companies and one of the key questions that came up over and over again was their IP position. We have a current Fortune 500 client, Chevron-Texaco, and they filed over 20 patents now in nanotechnology in the project that we're working one. Of course, a start-up company, start-up companies essentially are formed in the nano world when you have IP. If you don't have IP, you really don't have a start-up company. And so this would lead to the question of, is intellectual property or patents important? Well, I think we've already answered that, but I've taken this quote from the Nanosys website - for those who don't know, Nanosys is probably the most visible nanotech company in the world and it's here in Silicon Valley, and they're highly visible and they raised a lot of money. And on the website they claim they want - their strategy is "build a dominate technology, intellectual property estate through a combination of aggressive technology in licensing, teaming with the world's leaders in academic nanoscience, internal technology development, and discovery and patent filing." So essentially, they're touching on IP in three places. So, obviously, very, very important for nano.

The former speaker talked the U.S. Patent Office so I thought I'd talk a little bit about that. I've talked to some current patent attorneys who are practicing, specifically from Burns Donn, which is an IP firm. They have an office right across from the Patent Office in Virginia. So I talked to one of the partners there and his point was that they're good people, but they're overworked. They had a history of, just as we heard from the previous speaker, that there were many patents filed that were overlapping. That was going to cause some problems. He doesn't believe that's a problem anymore, but he does believe that the Patent Office is over tasked and understaffed.

One of the things that came up through doing this report for the California Council on Science and Technology was that Congress has diverted 650 million dollars from the PTO. This is funds that they generated - they're a self-funding organization and this is funds that they've generated from patent filings. Congress has taken the money and put it somewhere else. So it would be nice if the PTO, at least, was able to keep the money and hire some more folks and train them on the area of nano.

Okay, so talking a little bit - I'm glad no one brought up these issues of so I have something to talk about still, and didn't kill my slides - the issues of kind of where the U.S. sits versus the rest of the world. An interesting finding that was just published by Chad Weiland in the most recent issue of SMALL TIMES, is that U.S. firms are filing patents at a ratio of 7-1, versus foreign. But the amount of investment in the U.S. is comparable to foreign firms. So this says that we're following a lot of IP, but not so much on the investment - we're not ahead on the investment side. So this would lead one to believe that the U.S. would be in a

position of a patent enforcer in the future and perhaps, not a manufacturer of nanotechnology, or not a dominate one, which of course is a concern for us.

Now, that some of the background. I going to do a little bit of talking about, you know, from all of our looking at these companies - big, small, you know, small high flying and small low flying - what are some of the different strategies that we've seen people are taking in terms of patents? There is a company - and I haven't done research in this myself, I've been told about this - called Nano-Proprietary. They're really one extreme where it's an IP holding company. They're just going out and they're filing patents in front of other people with the intent of never making a product, but just waiting for those people to then infringe the patents in the future and then they'll come and they'll collect royalties. So, that's certainly one strategy, and they're focused in the flat panel area. That's pretty extreme.

Nanosys, which was already mentioned, which is really a high profile company almost seems like the same thing to me. I've talked to quite a few people. Nanosys is a Bay Area company. Actually, our firm was involved in doing the Due Diligence for the lead investor in the last round of funding, so we got a chance to take a deep look. And as we talk - you know, everybody wants to talk about Nanosys and a lot of people think that Nanosys is an IP holding company because they are acquiring a large amount of IP and we even heard that last year that as they were acquiring IP, they were laying off some people. So it seemed like they were really just focusing on the IP. But I talked to one of their founders and he said "no," and in fact, that they are in developing product. They're just being very aggressive on the IP front. But they're clearly valuing IP, given the quote I gave you before from them.

The typical nano start-up company that have seen has very little IP. Like I said, you really don't have a nano company if you don't have some IP. You don't have anything. So typically they'll license a patent, hopefully, exclusively - and usually they license it from universities. This is one of the things, I have seen any statistics on this, but this is our antidotal observation of looking at a bunch of companies is that most people who license IP get it from a university, not from a government lab. So the license of IP maybe generate some of their own. Ususally they're tied up in the cost of the legal expense. They can't hire the lawyers to and file more patents or to do a search. I think that that's a very important thing to do. Certainly, we're working with Chevron. You know, they have the budget to go out and just file all the patents that are necessary and they do a very good job of protecting themselves. So if you have a nano company which just has spotty - let's say the area of molecular memories. We looked a lot at that and it's an interesting area and we've heard a few speakers talk about it. You see so many people with - taking very similar ideas and they're all basically chasing architecture, which is similar to what HP is following, which leads me to the next line; HP. I think Stan Williams will be in the next panel. Stan is in charge of nanotech at HP, essentially. I may be simplifying it a bit. But he came and spoke at a forum that we run called the MIT-Stanford-Berkeley Nanotech Forum, and I asked his this question: "Well, what about IP? It seems like a big issue for the small companies, not the big companies." And he said, "Well, from HP's

point of view, they're just patenting, trying to make sure that no small company gets in their way." So, the big guy doesn't want to be held hostage by that company I had mentioned earlier, the Nano-Proprietary-type company. So it makes a difficult situation for the small company.

So, how may this unfold? Well, if you look at other industries and see how patents unfold in other industries, you can imagine things developing in different ways in the future. One is a mutually assured destruction. Nobody has a full solution in many areas, but many people have lots of partial solutions. But of course, they'll be forced to get along, so what typically will happen is more likely you'll have people with core patents and then people with derivatives around those core patents. So then you'll most likely see cross licensing. Now that's great for all those people who, you know the people with the core patents and the new folks, but once you have a big roll of cross licensing, it's very hard for anyone else to come in because they have nothing to trade, essentially.

If you look into some of the other areas like what happened in wireless, they came up with this policy - they realized there was a goal of making, really not using patents to exclude, but just making people pay. If I created an invention, we want you to pay for it, but we're not trying to exclude you from the market just because things like wireless, you want a lot of players. So they came up with what they call RNPP, which is Reasonable Nondiscriminatory Patent Policies. So, anybody can get in as long as you can pay the licensing fees, and those who create valuable IP get funded. And patent pooling is a similar idea. I don't want to go too much into it.

So, just to wrap up on this whole IP focus that I've been on, is what can California do to improve its situation in nano with respect to IP? Well, one fact that I've learned from talking to patent attorneys is that California is number one in filing for patents. So the question is how do we maintain that position and equally or more importantly is how do we convert this position into revitalized industry? Being an ex-Silicon guy in Silicon Valley, I'm very interested in hearing how we can do that.

So, you can imagine ways to incentivize people to file patents in California through tax incentives. Also, I think it helps the U.S., California differentially, because we are filing more patents than the U.S., in general, if we were to push the U.S. PTO to hire more staff. So those are just a few ideas.

That's it.

JACKSON: All right, thank you. The clock is hidden, so the question is, do we have time for questions, or do we need to move one?

(Response inaudible)

JACKSON: All right. Well, why don't we do that and shall we keep people here? So we will take this as a five-minute break, but if people have questions from the audience and all, we can take them, as well. You can ask while you're stretching. It's okay if you wan to get up. Any questions? Yes, sir.

DON MURPHY: My name is Don Murphy, but I have lots of years of industry experience in microelectronics business and I'd like to point out that, while we're talking about intellectual property, that there are two basic kinds of industries. Most of us tend of patents in the terms of the drug industry where if

you have a patent on one drug, you own the business for 17 years; nobody else can touch you. At the opposite extreme is microelectronics where everybody really has to work together because nobody owns everything, and that's the cross licensing. And I'd like to hear the panel address where they think nanotechnology is going to come in that spectrum, because to me, the main goal is, how do we advance the whole industry? And we really need, I think, a mechanism, as the last speaker talked, I kind of like the RNPP idea where you can't force somebody to just sit out because they don't own one crucial bit of intellectual property.

WAITZ: Well, let me answer that. The RNPP idea is appealing, but I'm afraid it may not take shape and the reason is, either the RNPP idea or this patent pooling, both of them are - patent pooling comes from audio/video encoding, like MP4. So both of those are industries where there's a network effect where the more the network does well, everybody in the network does well. So you want to populate the standard, either a CDMA cell phone or some form of encoding. In nanotech, you know, nanotech is back to hardware. If I have a better molecular memory, I don't want to share any piece of that. So, I think it's going to be much more of a mish-mash of patents. I see Stan back there. When he's up next, maybe he can address this issue again, but I think it's going to be just a big mish-mash of patents because we looked at all these molecular companies and some of these are going down the same crossbar architecture. And they're just going to have to license a whole bunch of ideas. Kind of how to take their concept and get it out to the outside world. It's kind of a whole stack of - the system, you have to have all the pieces and if different pieces are owned by different folks, it will really become a poker game with who has the most chips.

MILLER: I agree and I think that - we discuss patent pooling a lot in the book, and that the primary reason why it doesn't work is because the large companies like HP and IBM have an incentive to use their dominant patent portfolios to, basically, beat up on small start-up companies and exclude them as their potential competitors. So, the have no incentive to share.

One possibility that we've explored is the idea of horizontal consolidation with nanotech start-up companies and I think that there's a few areas where this would be right and one example would be carbon nanotubes, where there's lots of start-up companies with similar intellectual property competing to develop similar products. That would be right for some mergers between those start-ups. That would kind of eliminate some of the intellectual property conflict.

JACKSON: All right. There was one more question in the back and then I think we will have used up our five minutes.

LORNA MOFFETT: I have two questions. The first is is the public going to be able to address any of its concerns at this meeting before it's adjourned?

JACKSON: I believe we're taking some questions now. We're assuming it's public input.

LORNA MOFFETT: Is it possible for me to put my little public input at this time, or do I just get to ask a question?

JACKSON: Well, we could probably do in about 60 seconds and then I'm sure that there will be people who will be staying afterwards who would be happy to answer and continue the discussion.

LORNA MOFFETT: Okay. I am Lorna Moffett and I have a public access television program and I am spending all my time this year to alert the public of the dangers of nanotechnology that I do not feel have been properly addressed at this meeting at all. I came all the way from Monterey in the hopes that that's what we were going to be talking about because we need an immediate moratorium on this industry until we have tests. We only have three tests now for nanotubes that get into the environment and into our cells and one says it's highly toxic, which is NASA's test. Another says that it isn't toxic at all, which is Dupont, and then there's another test in which it says, "yeah, it's kind of iffy." This is just a small little example. We're using sunscreens that have tons of this stuff. We're washing it down into our streams, our water supply. We can't filter it out. Our cells have no idea that these nanotubes are in our cells. They have no immune response to them because it's totally uninvented in nature. We have an emergency situation here and we need to address that passionately as we never did with bioengineering or nuclear power, or we are just not going to make it as a human species and we don't deserve to. And we really have to take this seriously. And I ask this gentlemen here who made the statement that he feels that the benefits outweigh the risks, we don't even know the risks, so how can we know that they don't outweigh the benefits? And I wish to submit to you for your wonderful statement from Martin Luther King evidence to the contrary that we need a moratorium on this in California and everywhere in the world until we get it straight, our science.

JACKSON: Thank you. I think, perhaps, this might be an opportunity, Miss Peterson, if you - do you have any kind of response or any thoughts on this since it is something that you have been looking into?

PETERSON: Yes, this is not my area of expertise, but - and we haven't talked about it much here - but these issues are being addressed at the federal level. There is research being done. In Europe they take a very strong view on this. They tend to quote the precautionary principle, which states that - the strong version of it states that you basically don't go forward until you can prove safety. Now this isn't really how we have done things in the United States. This is not how technology has developed here and what we found in the past is that you move forward with technology, issues arise, and then you do work on those issues, and eventually it's dealt with. I think these are serious issues, but they are beginning to be looked at. I haven't heard anything conclusive to say that there is a major problem here. Some very serious folks are looking at it and I think it's something we should keep an eye on. I would say a moratorium is not the way to go; I would say, personally. On the other hand, it's true that the sunscreens do contain nanoparticles and I don't have any little kids, but if I did, I might think twice about that. So, these are issues, but I think they are starting to be looked at and I think California should play a role in those safety issues, too.

JACKSON: Thank you. I think that, on an interesting note, concludes that discussion and I thank all of you for participating and hope that you'll stay around

and that at the end we can continue the discussion on a more informal basis. Thank you all very much.

The next panel could come up.

BOWEN: Let me ask Stan Williams, Derrick Boston, Dr. Eric Werwa, and Cecilia von Beroldingen to come up.

VASCONCELLOS: I've got to leave at four for a meeting on the budget, trying to figure out how to protect the money for higher education so we can fund the workforce for this industry. Let me indicate that, you know, the way this place works, there are only 40 senators for 34 million people. Senator Bowen had three committees this afternoon, I've had two all day, we're back and forth, and as we leave - with term limits there's not much continuity anymore, the person I'm going to recommend to take my place in this co-chairmanship in the Senate is Senator Bowen. So I am please to have the person who has shown the most interest in these matters over the last several years moderate the next panel. Debra.

BOWEN: Thank you very much. First let me say that as I mentioned at the beginning, some of what we're trying to do here is learn about these technologies so that we can do a better job of assessing risks and the social and ethical implications of our great creativity and inventiveness. And I've been increasingly concerned over the last few years that, in particular with a legislature that's term limited, where members come and go, even more rapidly on the Assembly side than in the Senate side, that we don't have a good long-term mechanism for the kind of work that this committee does; that seeks to identify and understand emerging technologies and begin to evaluate the social, legal, and ethical implications of what we're doing before we get so far down the road that we do something that we later regret.

So with that in mind, the final panel is one on governance. We talk about the role of the governments in these matters and in particular, I am interested in creating a better method for raising the kinds of issues that the woman who was just here brought up, which I think are extremely important to all of us. They have an implication, certainly, on the venture capital and funding communities, as well as those who are working in the industry.

So, we have a terrific panel here. We have people who have just amazing stellar qualifications and I am delighted to have here. We will begin with Stan Williams from Hewlett-Packard. He is always exciting and interesting to listen to.

STAN WILLIAMS: Well thank you very much, Senator Bowen, and I'd like to thank Senator Vasconcellos and your two staffs for inviting me to come here today and to speak with you.

What I'd like to do is start off by looking at this issue of applications of nanotechnology. I like to go around making this somewhat provocative statement that the age of computing has not yet begun. If we look all the way back to the wonderful statements that we've heard earlier today and just look at what fundamental science tells us about what computing is all about. The amount of computing that we can do with the world's integrated circuits today is amazing. But in fact, from a fundamental scientific point of view, if you analyze our current level of integrated circuits, it actually should be possible to do all of the computing that's currently done with every computing machine on the face of

the earth in a little handheld device run on a double A battery. That's the challenge that we have going forward from today. I mean, exactly what we would all do with such devices I'm not sure. But, in fact, 50 years ago when the most powerful computer on the face of the earth was the ENIAC computer. The ENIAC computer was only about one one-billionth the power efficiency of today's current handheld PDAs. And of course, 50 years ago we had no idea that we would be sitting around with something that we could hold in our hand that would be much more powerful than any computing machine on the face of the earth and what we'd do with it. And, in fact, most of the time it's actually off. But having a machine that is effectively that powerful will really transform the way we work, the way we play, the way we understand ourselves and the world around us.

VASCONCELLOS: Before you proceed, let me say something. I've been here, this is my 38th year in the Legislature, and I've done a number of studies and reports that lead to similar action. And oftentimes sitting in the hearing, I get a flash for the cover for the cover for the report. And the cover of this report ought to have your quote about the amount of computing being on one A battery. I said to Heather, "That's our quote for the cover." So no one can miss the fact this is very momentous and daunting.

WILLIAMS: Well, thank you. I'd be happy to actually supply the calculations that show that's possible.

VASCONCELLOS: I have no doubt about your integrity so I don't need those, but we'll put those in the Appendix somewhere, for sure. Thanks, Stan.

WILLIAMS: Now the issue is that over the past 40 years, really, the integrated circuit has made California and the United States affluent. And the question that you really have is how did we get to the stage where we are now? Well, in the early 1960s the U.S. Federal government was spending, or I should say investing, two percent of the entire U.S. GNP in research and development. Almost all of that was going into physical sciences and engineering. That was what we spent in order to, essentially, do the moon program and the defense issues of the day. Now, that money - that investment in the 1960s was what brought me into the sciences in the first place. I was a young impressionable kid, I saw all this stuff I thought it was very exciting and that's what I wanted to do with my life. And a lot of my cohorts felt the same way. Now it turns out that in discussions that I've had with Marilea Mayo, who is with something called the Government-University-Industry Research Roundtable, which is sponsored by the National Academy of Sciences, I proposed an idea to her, and what I said was, "You know, I will bet that what's happened over the past 50 years is that the number of American students who have gone from high school into universities to study science has been largely influenced by the amount of money spent by the federal government on R&D." And so she actually went off and sponsored a study on this and came back and showed me a very, very interesting graph tracking the number of American students going to school in science and engineering, broken down by field, and the amount of money spent by the federal government, or invested by the federal government in these various areas over a period of time. And it turns out that there has been an exact correlation over that time. So if you ask, why don't we have the number of people that we need in the

workforce today? If you actually look at the federal R&D dollars, by almost any measure, they are done significantly in any type of real terms. When you look at it as a function of GNP, the amount of federal dollars going into investing in this area, although we talk about billions and billions of dollars, it still is a fraction of GNP. It's almost of factor of 10 down of what this country was investing in the '60s.

So as an issue, this is something that we're really looking at there. How do we go forward?

Now if I look within my own research group at Hewlett-Packard, which is really one of, if not the largest, industrial nanotechnology groups in the United States, it turn out that 31 out of the last 33 people that have hired were born outside of the United States. If it weren't for those people, my group wouldn't exist, and I am absolutely delighted and thankful for the tremendous talent of these people that we've brought in. But I do scratch my head and I wonder, why is it that I've only been able to identify two people born in the United States in the something like the past six or seven years when hiring people into my group?

VASCONCELLOS: I have to interrupt again. This is the third time you've been here and each time I learn more and more and I appreciate your vision. But in the field of computing - you know, I'm on the Board of Joint Venture-Silicon Valley and we track the development of the Valley and it's remarkable explosion of talent and creativity. And at one point it was clear that we were more and more looking overseas for people to come to work here. I am not at all opposed to all that except the people here weren't being prepared for the jobs. And in East San Jose, where there are in my district a lot of people who are more newly arrived, but terrifically negatively talented in my estimation and understanding of human nature, weren't being prepared to be qualified. We finally got to the point where we had a study done for the Joint Venture by some high-falootend carnie company. The cost to high tech for not having a business workforce in the Silicon Valley alone was three billion dollars a year. So it's really time that we grapple with those figures and figure out to make the schools such that they prepare people to be eligible to compete for the jobs that you are talking about.

WILLIAMS: And that is exactly my final point. I think that in many ways the - I continually ask myself, why is it that people are not, who are born in this country, are not pursuing these types of opportunities. The area is exciting to work in. It's intellectually stimulating. It's rewarding. And, yet, somehow there is this idea that it's just too hard. You know, you have to be some sort of egghead or something like that in order to be able to work in this area. And although it is a lot hard work, it doesn't take any tremendous genius to be able to work in this area and contribute substantially. And so I think that we do have to look to the educational system. We do have to encourage people and demystify what it is that's going on here. This whole issue of a moratorium I think is the craziest and last thing that we'd ever want to think about doing because, of course, then that's burying your head in the sand and not really understanding what the issues really are. But in terms of education, I have young people actually do come up to me and ask me, what should I study in order to become a nanotechnologist, I'm really interested in this? And they get this advice from people to, oh, they've got to take

all of these courses in biology and physics, and chemistry, and they have to do everything; and I tell them, no, no, no, that's actually the wrong thing because if you become too broad, you're absolutely useless. We have too many people who are paper-thin and with no depth to them already. What I tell them is, find something that you like - it doesn't even matter what it is - find something that you like and are deeply passionate about and do that extremely well. But the one thing that you should do besides that, or in addition to that, is take journalism classes or language classes or something. Learn how to communicate and how to listen, as you people do here. How to interact with people from wildly different backgrounds and diverse experiences and different cultures. And whether those cultures are because of national and ethnic background or just simply academic discipline, learn how to communicate across those cultural divides and learn how to work together. Because in today's scientific and engineering enterprise, the eureka moment is no longer one lone person struggling at night in the laboratory and all of a sudden having some flash of insight and saying, "Yes, I've got it." It's almost always today two or more people with very different backgrounds, both culturally and scientifically, talking to each other and all of a sudden realizing that together they can do something that neither one of them could have done alone. And so I think that that's really a large part of what we need to be able to do. We need to be able to have our young people understand how to communicate with each other, how to communicate across boundaries, make other people understand what it is that you are able to do and what your interests are, and then be able to get some feedback loop going into this issue. And it's really that part of the educational process that I think that we're missing and that I would like to see moving forward because with that, people can teach each other. One thing that we're going to find going forward is that no industry - no industry - is going to last longer than 10 years. What we're going to see is that technological change is going to come along and change things so rapidly, that the idea of a career as we know think of it today, is not going to exist. So the only way that we are going to continually be able be refreshed is to refresh each other and to teach each other and to build as we go forward to make sure that we're continually surfing whatever new wave that it is. Because we simply cannot control them as they're coming in.

Thank you very much.

VASCONCELLOS: Maybe the graphic on the cover of that report is surfing this new wave of nanotechnolgy.

BOWEN: Well, you know, I actually think, in thinking about that and the 10 year cycle, I have to note that in January, I think it was 22nd, of 1994, which is now almost exactly 10 years ago, the state of California unveiled its first computer-based availability to legislative information. And it wasn't a website because Mosaic hadn't been written. There was no worldwide web. And we had a battle in 2003 and Senator Vasconcellos helped me get the bill passed that put the California Legislature online, and it was an enormous struggle. At this point, it seems quaint and the early front end, if I could show it to you, would make you laugh because it was so difficult to use. But at least it existed and we started down the road, even though everything we did at that point is, through the cycle

of creative destruction, is no longer useable. It's sort of the eight-track tape of public access, electronic access to the Legislature. So, we've observed that, even here, and I think it's something that Senator Vasconcellos has talked a lot about in learning to learn. But I think your message also really brings us back to the outreach issues. It was much less subtle when I was a high school student in Rockford, Illinois, and was not allowed to take a mechanical drawing class because of my gender. I don't believe that would happen anywhere now in California. It kept me from becoming an engineer, which in the end is probably a good thing because I get to play one in the Senate, or at least, play with engineers and learn what they're doing in a lot of disciplines.

But I think we still send a lot of messages to young people about things being too hard or beyond their reach. And it is the reason that programs like the AVID program, the Challenger program at CSU Dominguez Hills that uses - you can go into a mock space ship in the capsule on the control panel. Students in the eighth grade can go in and have the experience of what it would be like to at Mission Control or in the space capsule. Those kinds of program are really critical to exposing students to a lot of things that they wouldn't know existed and possibilities that they just wouldn't have before them. So I think it will be one of our focuses when we deal with budget issues. How do we continue to make sure that we open the range of possibilities to the students who are in junior high now, which as someone pointed out, will be the scientists who are doing all of this 10 years from now?

Let's go on to Derrick Boston, California Nanosystems Institute. Thank you very much for joining us.

DERRICK BOSTON: Thank you very much. Thank you, Senators, it's a pleasure to be here. Thank you for the opportunity. My name is Derrick Boston and I am the Senior Vice President of the California Nanosystems Institute, and today I'd like to spend some time on three topics. First off I'd like to give you a progress report of what's been happening at CNSI; second, I'd like to talk about the State's investment in CNSI; and third, I'd like to talk about the challenges facing tech transfer from the university to the marketplace.

Let's start with the progress report, and I feel like something of a herald because I'm coming with good news from Southern California. A lot is happening. We've actually been flying below the radar, but here is what we've been up to.

CNSI's mission is to basically maintain or extend California's leadership in nanotechnology. And in order to achieve that objective, we have a number of specific goals. First off, we look to speed the transfer of technology from the lab to the marketplace. And we're trying to do that by becoming, in essence, a vertically-integrated organization from the lab to as close to the marketplace as we can get.

Now what does that mean? It means that we want to be able to nurture technology from the idea stage through products and application development as far as we can and the various rungs of that ladder are as follows:

One, we start with fundamental research. That is the source of all ideas. And at UCLA we are in the midst of constructing a state-of-the-art facility that will

be 180,000 square feet in size. At UC Santa Barbara they're constructing a facility that will be 120,000 square feet. So, we will have significant capacity that we believe will rival anything in the state or in the rest of the country. We have researchers who are at the leading edge of a broad range of nanotechnology disciplines, everything from materials through life sciences through to electronics and information technology who are making contributions in all those fronts.

But the next rung of the ladder that we are looking at is to bring industry in early on to get input from business to make sure that we are focusing toward our research, towards commercially viable applications of nanotechnology. And we have a number of conduits for that so far. We've put together a business advisory board whose members read like a who's who of nanotechnology. We have senior managers and scientists from a number of large companies that are investing and working in nanotechnology, everyone from Agilent, Amgen, Kiron, GE, IBM, Intel. As well as partners at major VC firms that have invested in nanotech, so Draper-Fisher, Apax, Harris and Harris. We have begun conversations with all of them to learn from them what are some of the applications that make sense? What are the addressable markets? We have put together what we're calling "technology and business forums," where we talk about our technology within a business context. Again, what are the applications and markets? We have a forum coming up the coming Friday. Another conduit is a series of post-Dot fellowships where we're working initially with HP and hoping to extend that to other companies where we'll place post-Dots on projects that are of relevance and interest to industry to begin that cross fertilization…

BOWEN: Funded how?

BOSTON: HP has been the donor, one of our largest sponsors, and it is from those funds that we are initially putting this together.

BOWEN: These have been industry-funded, not taxpayer-funded.

BOSTON: Exactly, not taxpayer-funded at present. Yes.

So, through that input, then, we hopefully push the idea towards a commercially viable application. The next level, then, is to try to nurture it. To find potential users or developers, or to develop it through a start-up. And we have partnered with the Girvin Institute, which is a nonprofit foundation based up here at Moffett Field, which has developed the infrastructure to do two things. One, to showcase technology. They've put together a database that includes not only IP, but also the companies that may use them, big and small. And so we will use that mechanism to find potential users. But they also run an incubator, a way of nurturing small companies. We are actually going to create one in Southern California to take companies to the next stage.

And then perhaps the final rung that we'll put in place would ultimately be some ability to add funding, to continue the process of development, to get to an application or a product.

So that's what we're doing in terms of trying to bridge that gap from lab to marketplace, and that's one our major goals.

The second major goal is education, to develop the next generation of nanotech scholars and researchers. And we're doing a number of things there.

First off, this past summer we put together a curriculum for high school students, as well as a kit of experiments that would introduce them to nanotechology. We did this in collaboration with the School of Education at UCLA and we brought in high school science teachers from LAUSD, the Los Angeles Unified School District, and gave them instruction how to teach about nanotechnology. And that curriculum is being taught during this school year.

On an informal level, we have a faculty member who put together an interactive display that's now running at the LA County Museum of Art, which is intended for kids, but is very entertaining for adults, as well. And I'd invite anyone who is in LA who would like to spend an interesting afternoon to go through and look at what's there.

BOWEN: You and I will get together and pick a date and host legislators from other parts of the state if they want to come down.

BOSTON: I'll take you up on that. And I have something else to seek your input on. But that is a way of generating excitement. Win kids about science and engineering in order to begin funneling them toward programs. At the university level we've put together a number of courses that cover everything from nanomanufacturing through to bioengineering, and we're looking at pulling degree programs together around that. So that's our second specific objective.

The third objective is to address issues of societal implications, to generate public understanding and awareness of nanotechnology. We are in the midst of putting together a proposal to seek federal funding that is part of the recently passed funding initiative in order to become a center for that discussion. We feel that's a very important part of what we're doing and we hoping, actually, to partner with a very important think tank that would be part of our proposal.

The final specific objective that we have is to generate regional economic development around nanotechnology. We're hoping to put together a mini summit of key players from government, from industry and academia, the research labs in order to talk about and generate a specific plan of action in order to generate economic development in the Southern California-LA-Santa Barbara region. And I would invite you, specifically, to participate in that if we can work out your schedule.

So those are our objectives and how we are moving forward. And that's sort of a progress report which then leads me to my second discussion point which is state investment in CNSI.

The fact is that the state of California will, when everything is said and done, when the two buildings are constructed, will have financed just under 200 million dollars worth of activity at CNSI. That makes us the largest single investment that California has made in nanotechnology, and unfortunately, that point is not in the report that was placed before you and I think it is a major shortcoming of that report. It may, in part, be our fault because we haven't gotten the word out as much as we'd like to, and we're working on that. But when you, in this committee and in the Legislature, think about implementing the various proposals that are in that report. When you think about your committees and taskforces, creating your ethics centers, looking at ways of economic development, we already have an infrastructure that we are building and

momentum around all of those issues. And while we're not asking you to put all your money in one basket, because I think that would be unwise for a number of reasons, we do think that we should be very high on the priority list because we do have that infrastructure.

BOWEN: Let me ask you a couple of questions. Is your building where the new Engineering Building is going up at UCLA?

BOSTON: Yeah, it's right in that complex in that area, exactly. It's underway. Ground was broken in early 2003 and we expect to be completed in late 2005.

BOWEN: And what do you have underway in terms of dealing with societal and ethical impact of nanotech, in specific, although I am interested in a more broad range of technology?

BOSTON: Right. We are pulling together the partners to have that discussion. From our standpoint, we have a large vested interest in nano and in R&D. And there is the obvious sort of critique that then can be raised that we are, perhaps, too biased. So we are bringing in other parties. So we're bringing in a major think tank, which I can't name at present, but which brings significant objectivity and analytical tools across the broad range of societal issues, whether you are talking about workforce issues and training and retraining of workers, or environmental and health concerns, so that we can together - we would link their significant with our understanding of the science to really engage in a meaningful and reasonable discussion about those issues.

BOWEN: One of the things that I see happening is that as each technology comes along, someone has to reinvent or create a whole structure to deal with these issues. You're dealing with it in nanotech. I've been dealing with it with a group of people who are working on radio frequency information devices and, primarily, privacy concerns of what happens if every can of Diet Dr. Pepper knows where I took it, just to pick an example out of thin air. And there are many other examples, but we don't have the ability to learn from other structures, things that have worked. Even to learn in a way that doesn't, obviously, stamp on your funding sources, but funding is always an issue for these kinds of efforts. And we don't even have a way to say, well, here's how the funding went for this once it's completed. So that the next group working on the next emerging technology aren't sitting, struggling, trying to figure out how to assemble a representative group of people.

This panel is called "governance." It's mostly not about that, but I think we should do a follow-up more specifically on this governance issue, and probably governance is not the right term. But it is more an institutionalized structure for addressing these issues so that not everyone has to do this on an ad hoc basis. Because the amount of time that gets expended putting it all together I think is greater than what's needed to accomplish the task.

BOSTON: I agree. I agree, and we're actually trying to shortcut the process by partnering with this think tank because they have looked at these issues and concerns in biotech, with robotics, with a number of other high tech areas. And so we're not reinventing the wheel. We're able to use the various

tools that they already have. But in terms pulling people together, you are absolutely correct.

BOWEN: And then at some point all of that has to get translated or filtered up to where we are so that privacy concerns, the kinds of environmental concerns, ethical concerns can get dealt with by policymakers. And so far, until this particular committee, there's been a pretty large disconnect between the people who are actually doing the work and the people who are responsible for policy, which is why at the beginning of this I said mostly we feel like we're running around chasing after technologies that have a lot of good and sometimes some things that we ought to be dealing with. So trying to find a way to engage policymakers, legislators, staffers, people at the federal level, the local level, earlier on so that we can grapple with these issues together in a collaborative manner that gets these concerns out in the open, I think is a real challenge for democracy, as well as for you who are actually out there doing the work.

BOSTON: Right. And we would hope that once we bring people together in this sort of mini summit, that we will bring them back again periodically and establish a network that will stay in touch. It's a lot of work to bring everyone together in the first place and then we need to make sure that we keep that mechanism going.

I know time is short so I just go very quickly to the third item, which is the tech transfer challenge, which is probably the largest challenge that we face.

We are sort of an interesting animal at the University. We are focused on getting technology out of the lab and into the marketplace. As everyone knows, and it's in the report, the UC system, in general, and unfortunately, UCLA and UC Santa Barbara, in particular, are notorious for the difficulties that face tech transfer. And while the UC system may not be fully within the jurisdiction of the Legislature, to the extent that you are interested in seeing nanotechnology become an engine for growth in California, we would suggest that changes in the way that the IP transfer process occurs would be one very important place to start with what you do. We are pushing at our end, but the more hands on these oars, the better. So, with that I'll leave it there, unless there are other questions.

BOWEN: Right. That's great. I think that's another subject matter that worthy of some follow-up. We do not control the UC. It is an independent system, but we do have - we normally have more funding than we have this year. So, we have worked collaboratively with folks who like to see part of their funding come from the state. But I do think that the tech transfer, and someone asked me a question at the break about the state's potential role in the middle part of the - after you've got the technology, before it's clearly commercial. And we did a hearing, probably a year or so ago, with the California Public Employees Retirement System officials who have a small amount of money that's allocated specifically to biotech, I believe. And it is intended to nurture ventures in California that will return benefits to California taxpayers in the long run. And because the CalPERS fund is so large, there's room for some risk-taking in a small amount of the portfolio that probably most of us here in the room couldn't really do on our own, out of our own portfolios in any kind of significant way. But I think it would be time, as well, to bring CalPERS and maybe STRS, the State

Teachers Retirement fund, back in to look at how we reinvest in California's emerging industries in a way that eventually has the ability to help keep funding education by reducing, for example, the amount that we need to contribute to the teachers' retirement programs from the general fund. So, I think we'll do that and we'll take a look at what other kinds of venture capital… Yes. Come on up to the mike.

BOSTON: Just one point on that, the Director of Alternative Investments of CalSTRS is on our Business Advisory Board. So, we've already brought them into the process.

BOWEN: That's good, but the difficulty with all of this always is corralling all the available information and making it available. And the fact that many of us in this room are learning about some of these linkages for the first time is part of the reason we do this.

Mr. Hurd, welcome back.

HURD: Thanks. Quick thing, CalPERS, I believe, is invested in at least one nanotech company directly, and also I believe has also partly funded garage technology ventures to seed California start-ups. So just some background.

BOWEN: I know the capability is there and that there's a fund and it's been awhile since we've done that little discussion, but the commitment is there. And Phil Angelides as Treasurer, I think, has helped push that saying, "Let's invest in our people and our own ventures" - not that we don't want a broader view, but if we can do good by doing well, do it.

So, thank you very much for being here. We are running a little late. Let me go to former Assemblyman Mike Honda's staffer who has come out to join us from Washington, D.C., Dr. Eric Werwa. Did I slaughter your last name?

DR. ERIC WERWA: Werwa, and I bring my regrets from Congressman Honda for his inability to be here today, but the State of the Union begins in a few minutes now, or a couple of hours. So he is back in Washington, but he wanted to be sure that his voice was heard here to give you a report back on what's happened in Washington, what continues to happen, and how he would like to work with the state to help bolster nanotechnology within California.

First off, to echo what Senator Vasconcellos asked about earlier about how would be take this report and the findings back to the congressional delegation. We would be happy to be the conduit by which that happens. I actually talked with Susan and we'd love to be able to pull together the delegation. We have a lot of support from other members already at other events we've held and on the bill co-sponsorship. So, we can work with that.

BOWEN: And you refer to the bill. I know about it, but probably you should give a thumbnail…

WERWA: Yeah, I'll get to it in one second. I don't think I need to go on too much about it here, but why should the federal government be investing in nanotechnology? Well, there's a lot of stuff out there that's going to take some long-term research. We've seen the tennis balls that are here today, but to take that long-term view on several of these break-though technologies requires the outlook that the federal government is probably one of the few entities that can take. And so, the National Technology Initiative was created to do that and then

last year, Congressman Honda and Congressman Boehlert from New York introduced legislation on the House side. There are all sorts of details, but in December the President signed the 21st Century Nanotechnology Research and Development Act, which essentially authorizes into law the National Nanotechnology Initiative funding about 3.7 billion dollars over four years through several different agencies over which we have jurisdiction, the National Science Foundatiuon, Department of Energy, Environmental Protection Agency, NASA, the National Institute of Standards and Technology at the Department of Commerce. It doesn't specifically include the Department of Defense, which does a lot of nanotechnology research only because the committees don't have jurisdiction over those things.

BOWEN: They probably have their own funding source.

WERWA: They have their own funding stream that is will protected. And funding is going to go to investigator grants. A lot of researchers throughout California universities are funded through National Science Foundation, as well as centers - the Center for - I don't want to get the acronym wrong - Scalable Integrated Nanomanufacturing, which is a collaboration between UCLA, Berkeley, Stanford, UC San Diego, and Hewlett-Packard Labs is an NSF-funded project. The Department of Energy funds centers here in California. The Molecular Foundry groundbreaking is scheduled for next week at the Lawrence Berkeley Lab. So, some of this funding is coming back to California. And in addition to securing this funding in the legislatively authorized language, it also makes some changes to the way the program is organized in response to a report by the National Academy of Scientists, which cited some of the things we've heard about here today. The funding for societal ethical implications hasn't gone as well-used as would have been hoped.

BOWEN: We'll try to change that.

WERWA: Yeah, well part of the reorganization of the Nanotechnology Initiative under the legislation is to target why is that happening? How can we make this program more robust than it is today? And so some of those managerial changes are part of what's in the legislation and there's some more details in the information that I provided, and I won't dwell too much on this.

A lot of this is going to be targeted to helping increase the workforce and education. One of the gaps, though, that Congressman Honda had tried to address was this "valley of death" you were talking about, trying to provide funding to help with movement from the lab into the marketplace. And, really, we face at the Federal level a philosophical question. Is this a role that's appropriate for the federal government, or is it more appropriate for State or local government? And we're going to continue to keep trying to push on this and we'd love to have to have support. But I can't guarantee - and we have support from individuals from both sides of the isle in the House and they told Congressman Honda they like this idea, and people of the Department of Commerce, but none of that guarantees anything will actually happen. So that's my last note I'll sound, just ringing the gong here for California.

So this bill authorizes funding, only. Each year is going to be a fight to get this money spent, and so that's, I know, one of the priorities in your report and

that's one of the priorities for Congressman Honda. And that's what I get to do because I do nanotechnology. He's already been in touch with President Bush urging him, you know, you signed this bill into law, urging him to include in a budget request funding at those levels. We haven't seen the budget yet, but the process is just beginning and we will do all we can. But it would be greatly helpful to get calls from back home to members and senators saying, "Hey, get on board with this effort that Congressman Honda's leading to try to get this funded." That would help our battle a great deal, and then California can compete for the grants as it does.

On the bridging gap idea, I'm glad I had a chance to talk with Assemblyman Cogdill before he left. He had been asking about if there is a way that it can be done that kind of pays for itself? And in our research and trying to draft legislation, we learned that Massachusetts has a Technology Development Corporation that was not specifically targeted to nanotechnology, but was other technology development that originally was a joint investment by private investors and from the state. Now, it's self-funded. The investment that they made paid off, paid back the original investors, and created an extra pool of money that is now what drives it. We don't know if that's a model at the federal level or in the California level, but there are certain ways that it could be done that we're looking into and we would be very supportive of to not… I know that the budget situation is tough and so to propose that California should be go spending money is not a valuable answer unless you can come up with a way to do it that pays back.

So, I know my time is short, so I'll just say Congressman Honda sends his warm regards to everyone and would welcome any questions you have for him. Any ways we can work together. He looks forward to all those things, and if you have any questions, I'll be happy to answer them.

BOWEN: Great. Thank you. Our final witness, and if you could educate me as to the proper pronunciation of your surname, it would avoid me embarrassing myself by trying to do it.

CECILIA VON BEROLDINGEN: That's fine. My name is Cecilia von Beroldingen.

BOWEN: Good, I would have gotten it wrong. I'd like to welcome Cecilia von Beroldingen now from the California Department of Justice as our last panelist.

VON BEROLDINGEN: I've come to the Committee as a member of a government laboratory. I am the Laboratory Director of Method Development for the California Department of Justice Jan Bashishki DNA Laboratory in Point Richmond, and I come as other people in my field are beginning to look at the potential applications of nanotechnology to my own field. I brought a PowerPoint presentation to illustrate why we think nanotechnology will be of benefit, ultimately, to the area of forensic DNA analysis

BOWEN: A two-minute technical break? Then let me go back to Eric Werwa, if I might, while we're having a two-minute technical break and ask how much of the funding that was left on the table had been intended for projects that

dealt with the societal and ethical implications of nanotech? Do you know? Even in gross measure, not in nano measure?

WERWA: I don't know specifically. Are you asking of the total funding, or of the funding that was initially set aside for that?

BOWEN: You can pick.

WERWA: I don't have the answer to either one. In ballpark figures, I do know that the total amount of funding that was set aside for the societal, ethical, environmental, was fairly small. Say less than, definitely less that 10 percent of the total funding. There was a lot of talk after the - in the context of the human genome project, it was thought that 10 percent seemed like a good idea, or we should spend at least that much. So that was a target that had been set, but it had not achieved that target and even at that point - I don't know the exact number - and even given the amount that was set aside, less that was actually given out in grants.

BOWEN: And has someone done a failure analysis?

WERWA: Not yet, that I know of.

BOWEN: Looked at why that funding didn't go out? What the problem was? What…

WERWA: I don't if a formal - part of the report that the National…

BOWEN: That's probably long-term…

WERWA: Part of the report that the National Academies did that led to the legislation did look into that. Some of it was a result of - within the agencies, EPA didn't necessarily have a good mechanism for putting out a request for proposals to the right communities to get that. So they have been working to develop, since then, a way - how do they target the right audience? What is it that they seek proposals on? So they have looked back on that and are making changes.

BOWEN: All right. We have so much technology here…

WERWA: I know, I'm overwhelmed.

BOWEN: …and such a room full of experts that it's hard to know who to put in charge. And that our primary problem. Probably not technical, but organizational. If we had storage in nano form, of course, we wouldn't be worrying about… That's right. We need a self-healing, self-diagnostic…

WERWA: The whole computer could have been the size of that little key chain.

BOWEN: By the way, ENIAC, for anyone who has a chance to go to the Smithsonian, there is a display that includes ENIAC and you will be amazed. I don't think it's the whole machine because the whole machine…

VASCONCELLOS: The rest of it's in Moffett Field in Palo Alto.?

BOWEN: The rest of it's in Moffett Field? Can you view it, or is it…? Really? Okay.

Anyway, there's a pretty amazing display on the history of computing at the Smithsonian in Washington, D.C., that is highly recommended to anyone who can sneak away from their official business in order to get a little historical perspective on computing.

All right. That's faster than the Senate Help Desk has ever gotten to me and they are terrific. So you guys have done a fabulous job.

VON BEROLDINGEN: Okay. As I said, I'm with the California Department of Justice Jan Bashinski DNA Laboratory and, basically, what we are doing is looking towards future technologies to allow us to do what we do in the lab in a faster, better, cheaper method.

What I'd like to do is to briefly describe the current technologies we use in the lab and what we are moving towards, which is basically at this point in time, more microtechnology than nanotechnology. But we are looking toward the future to make improvements in the way that we do forensic DNA analysis.

What we have here is a brief series of slides that shows the current state of the art with regard to DNA testing in forensic labs, which is preparation of samples. In this particular case I believe we are looking preparation of a bone sample in Our Missing Persons DNA Program. It goes through various manipulations, including DNA extraction/purification, quantitation of the DNA, followed by amplification using PCR to amplify the regions of the genes that show differences between human beings. They are known as "STRs," and this is what we use for identification of the origin of a particular sample.

We run things on very macro machines like capillary electrophoresis, and this just shows you an example of that. Basically the point I'm trying to convey is that at the scale that we are now, even though we do employ robotic methodologies, DNA analysis takes several days. And the challenges that we are presented with are that we have a large number of convicted offender samples and case samples that need to be analyzed. There is the time and the personnel that's required to go through these analysis procedures and there's the costs of the materials and the facilities that are used to carryout these procedures.

So how are we overcoming these challenges? Well, right now we're looking towards what's been called "a lab on a chip." This is basically using the microchip technology that's been developed recently and applying it to methods of DNA analysis. And, just to briefly go through these slides. Basically, microchips provide a mechanism to do at a microscale things that are currently done at a macroscale. By miniaturization of devices, we can carryout all of the techniques that I demonstrated in those previous slides that were done at different places and time and space, and different rooms over a period of days and condense it down to a microchip platform. The result of this is that it would be more rapid, less expensive, and amenable to automation, which are all things that we would like to be able to do.

Basically, the microchip platform will allow us to automate and integrate all of the various steps in our DNA analysis process, eventually bringing it down it the goal, which is what is happening in medical diagnostics of providing analysis at the point of care. In our case, it's not the doctor's office or the hospital. In our case it might be the scene of the crime or it might be in the emergency room where a rape victim comes in to get a sample taken for DNA analysis from the perpetrator.

This is a device that is very diagrammatic of how one can achieve on a microchip all the various steps in the DNA analysis procedure that I illustrated in the very beginning of my talk. This shows designated areas where extraction, amplification, electrophoresis, and detection of the product occur.

This is, again, a similar slide. It's from the work of Dr. Richard Matthews at UC Berkeley who is developing microchip capabilities that will ultimately analyze hundreds of samples on a microchip.

One of the things that our lab is looking at, in particular, we have undertaken a research project to get involved in the front part of this reaction, which is to prepare cells for analysis. One of the problems we encounter in forensic DNA analysis, especially in sexual assault cases, is that we need to separate cells from different donors. If we could be able to separate sperm from epithelial cells from the female victim in a very rapid micro device, that would assist the ability to provide point of care analysis for these crime scene samples. And this is just an illustration of what that might look like.

There are other technologies on the horizon that are being developed. Many of these companies are located in California, including a company by the name of Appimetrics, who is developing a micro array platform to analyze many different genetic targets at once. Again, this is of interest to us in the forensic market because this is a very rapid way that we can use to identify the source of a crime scene sample.

So basically, we're going from macro to micro, but we're looking to nano and to what has been referred to as "nanobiotechnology." Even with the micro methods that are currently being developed for medical diagnostic and potentially, forensic applications, we're dealing with micro fluid systems that are working at the nanoliter scale. We're look at microarrays that are looking at subnanogram amounts of genetic materials. In the years to come, we will see a convergence of these technologies to provide platforms on a nanoscale that will make the analysis of DNA more sensitive and much more rapid.

Okay, so the perspective of forensic science in this technology - and this is the perspective of a practitioner who is looking at the potential benefits and implications of the technology - are that since the inception of forensic DNA analysis, we have been relying on research and development in academia and in industry to provide to us the technologies that we need to do our job. We capitalize on those technologies, but the ability to transfer the technology to the lab is a slow process. It's demanded of forensic DNA laboratories by federal standards that we go through thorough validation processes before we implement any sort of testing technology. And also, the validation process makes the methodology gain court acceptance.

With regard to past technologies that have been implemented in forensic DNA laboratories over the past few years, actually the past decade, what we've seen is that there are potential products that are out there that are being researched in academia and are being developed and commercialized by industry. But because the forensic DNA market is such a small part of the market share, those entities don't really have a lot of incentive to devote their efforts to development of those applications.

So to summarize, the criminal justice system depends upon the analysis of DNA to achieve justice in criminal cases. Forensic DNA laboratories, such as ours, are looking forward to these powerful new technologies, such as nanobiotechnology, as a way that will make our efforts more powerful and more

efficient. And we can be assisted in being able to perform our job of analyzing crime scene samples, as well as convicted offender samples, by the state promoting the development of new technologies such as nanobiotechnology, and in particular, providing incentives that would encourage industry to develop forensic applications for their technologies.

I think that's it and I appreciate being invited here to speak on this topic by the Committee. Thank you.

BOWEN: Thank you. I'm told by Heather Barbour that DOJ has applied for federal Do you know the status of that?

VON BEROLDINGEN: Actually, it's being submitted in two days. What we are planning to do, in fact I alluded to it earlier in my presentation, one of the things that we would like to be able to do is to develop or assist in the development of a miniaturized device that integrates all of the various steps in the DNA analysis procedure. And one area that is of particular value socially and to the criminal justice system is the analysis of sexual assault evidence. And if we can analyze that evidence as soon as possible, that not only provides investigation leads to law enforcement agencies, but we can use these new techniques - miniaturized devices - to take the analysis from isolation/separation of the sperm cells from the female cells all the way through to development of a DNA profile from the perpetrator on sight, potentially at the point of care, at the emergency room. And this would have tremendous applications. Our part in this procedure is to - our project is to develop a microchip analysis that would allow us to perform cell separation. The technique is called "dielectrophoresis," and it takes advantage of differences in properties of cells, volume, surface components, etc. They can be separated in a non-uniform electric field and on a microchip. And potentially that microchip could be interfaced into an integrated device that would carryout the entire process of DNA analysis in a very rapid timeframe, minutes.

BOWEN: Are you looking for help in your application, or support, I should say?

VON BEROLDINGEN: Right now we are looking for collaborators in academia who are experts in the area, but most of the work, since it involves working with human evidentiary-type samples, will probably be done in our laboratory.

BOWEN: I think by "support," I meant of this Committee. Support of the application.

VON BEROLDINGEN: Yes. I really hadn't thought of that.

MARK CHEKELBAIN: Mark Chekelbain, also of the Department of Justice. We would very much appreciate support from members of the Legislature from both sides of the isle and from Congressman Honda's office. We also have another grant in to the National Institute of Justice looking at a study with nanotechnology on tiny markings on the casings of bullets. That when a bullet leaves a firearm, the casing left behind at the crime scene - to look how we might be able to identify where that casing comes from. We just submitted that to do a study along with CHP, as well, also from the same division over at the Department of Justice.

BOWEN: Thank you. Does anyone in the audience have any questions of anyone of this panel? All right, if not, I asked Heather Barbour if she would be so kind as to give us a little list of projects that we've identified for - at least to be considered as - future work to be done with the hope that we'll get these up on the Committee's website and people out there can have a look at them. Help us refine them. Help us set a priority. And especially, tell us what we missed, which is probably one of the most valuable forms of input we get. Heather.

HEATHER BARBOUR: This isn't in any particular order, but we were going to, first and foremost, collect and post all the testimony. I've had a couple of people ask for that. So we'll do that to the website. Then we were talking about doing a legislative visit to CNSI and then also, potentially, as well, to Moffett. We wanted to follow-up on some of the tech transfer issues that got raised, follow-up on some of the issues about CalPERS and STRS and the investment power of the state. We also need to talk about some environmental issues and the question, you know, how do we follow up on that? And also, most importantly, is review the recommendations of the CCST report and look for next steps in terms of which of those recommendations need to move forward and how and where and when and all that.

BOWEN: Great, and I will add to that something that's been on my to-do list that I think has come out, implicitly, a number of things, which is to create a framework to deal with the legal, social, and ethical implications that are emerging technologies and the California Legislature. Like Senator Vasconcellos, I'm mindful of the fact that in December of 2006 I'll be walking out of this building as a Senator for the last time and I'd like to make it easier for whoever comes after me to be dealing with some of these issues. That's something very important to me, personally.

I want to thank all the panelists who cleared their schedule today to deal with this discussion of nanotechnology. I thought it was great to have a little example of a real-world application that is so obvious and simple that all of us with no technical background can understand how it might work. My colleagues and I serve on this Committee, we look forward to continuing our work with anybody who's interested in nanotech, both the pluses and the minuses, both the benefits and the risks, and with other emerging technologies. And we look forward to e-mail, or faxes, written correspondence, or telephone calls in no particular order from anyone watching on the California Channel who have any input on what we've done and what else we might consider. Someone once told me that feedback is the breakfast of champions. We don't always like to hear it, but we take the time to read it. We often learn a great deal. So I look forward to hearing comments from people who were not able to be with us in the committee room today. And once again, thank you to everyone who was here today and the hearing is adjourned. We will look for you on our website.

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